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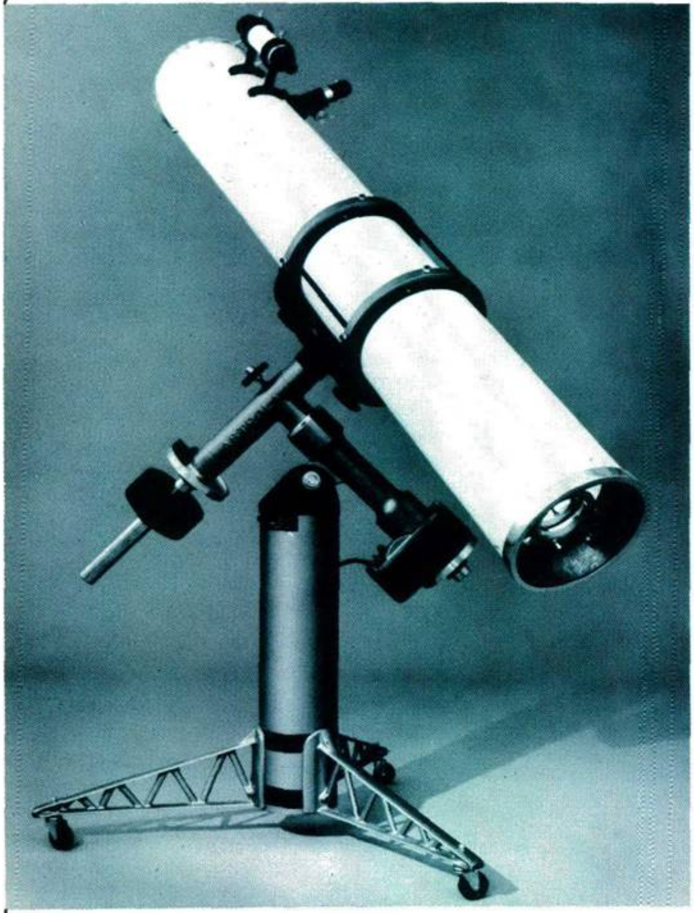

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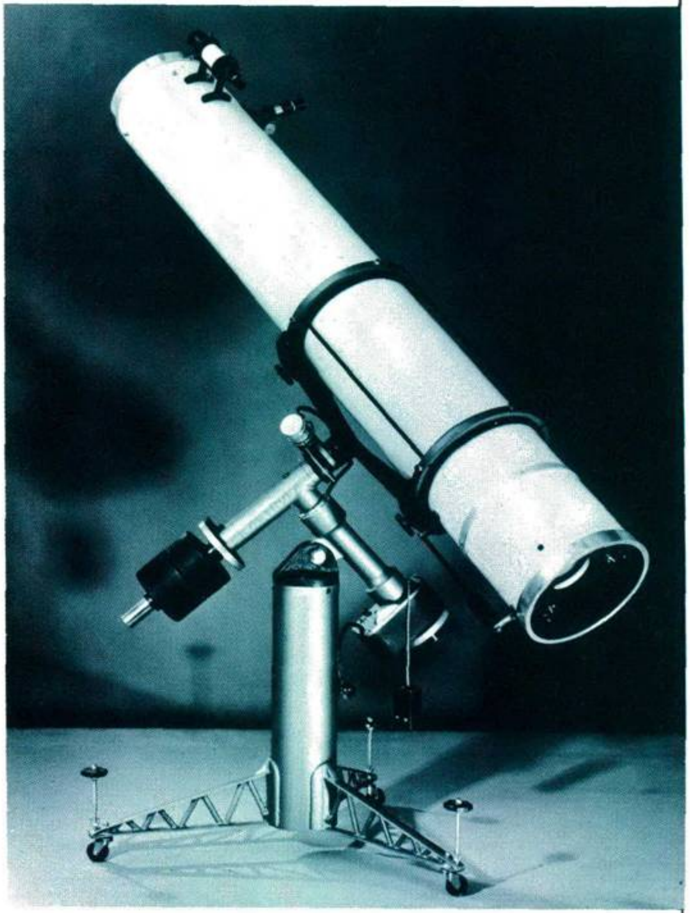

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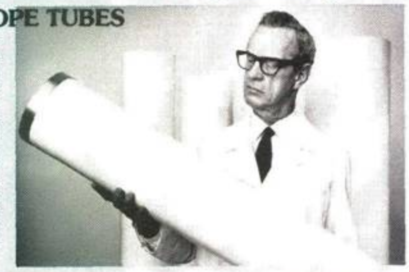

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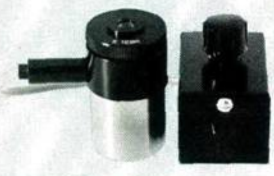

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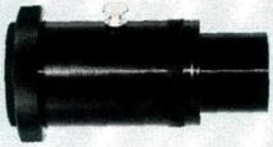

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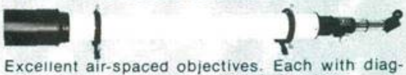

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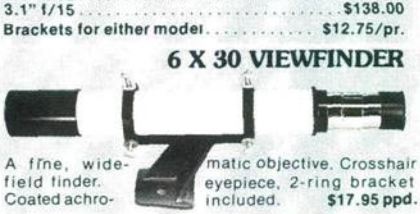

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PUBLISHER'S MEMO

Kitt Peak National Observatory has perceived unintended offense by me with regard to ASTRONOMY's offer of eight 8-1/2 x 11 inch reproductions of Kitt Peak photographs.

Briefly the background of the offer rests with a minisurvey of reader interest in artwork and photographs which I published in my November 1974 Publisher's Memo. I was surprised by the low level of interest in black and white reproductions in light of the fact that so many startlingly beautiful observatory photos have either never been published, or at least made widely available to the public.

And I eagerly wanted to make these photographs available to you even if it meant ASTRONOMY magazine might not make a profit from their offer. So I phoned Dave Moore, Public Information Director at Kitt Peak and discussed the possibility of offering the observatory's photos to ASTRONOMY readers. His immediate reaction was enthusiastic and positive. His approval was tentatively based on acceptance of the idea by higher authorities at Kitt Peak.

Since previous experience with the use of Kitt Peak photos started with this line of approval and had resulted in permission being granted ASTRONOMY, I proceeded with my first Publisher's Memo (February 1975) believing approval would be granted by the time readers responded. More than anything else my first memo was a "fishing expedition" to determine whether readers might be more interested in black and white photographs if a specific offer was made. Furthermore, it was necessary to see whether at least 500 sets could be sold at $2.00 per set so ASTRONOMY could at least break even on the offer.

The first memo brought us halfway home. And I was prepared to scrap the offer at that time as financially infeasible. However, before I made my final decision, I again phoned Dave Moore to see whether he had received approval from his superiors. During our conversation we discussed many things and I was left with the erroneous impression that approval had not yet been given because Kitt Peak might want to publish the photos themselves. Nonetheless, the matter was still being considered, so I decided to once more stir the reader pot to see whether a second memo would bring the needed 500 buyers to the surface.

The April Publisher's Memo did the trick, and by mid-May we had 500 buyers. I phoned Dave Moore with this information which he relayed to the proper Kitt Peak decision-makers. He felt their knowledge of strong reader interest would expedite approval.

By the end of May, I had still received no word from Kitt Peak concerning their decision on the photo offer. Since four months had passed and many subscribers had written second and third letters asking about the disposition of the offer, I felt it important to inform readers what was happening. I again called Dave Moore at Kitt Peak and was told the offer was still under consideration. Again I misunderstood that Kitt Peak might publish the photos themselves. So I drafted a letter to the subscribers who responded to my memos (which later became the basis for my July memo), and phoned Dave to see whether it met with his approval. He agreed with me that when ASTRONOMY readers started writing directly to Kitt Peak about the photo sets, a decision would be swiftly forthcoming.

Which brings me to the reason for this memo.

Since ASTRONOMY began, Kitt Peak National Observatory has been the most cooperative astronomical institution we have had the pleasure of dealing with. Its single-minded interest in, and concern for public dissemination of astronomical information has been a brilliantly shining star in an otherwise often times murky sea of frustrating bureaucracy. ASTRONOMY magazine has had and we hope will continue to have a particularly outstanding relationship with Kitt Peak. We regularly receive photographs and information for publication in ASTRONOMY with a freedom and cooperative spirit that should be the model and envy of other less enlightened astronomical organizations. We share a mutual concern for public understanding of astronomy. And frankly, our unique mutual goals, and the fine rapport they have built between us, make Kitt Peak and ASTRONOMY a team whose inadvertent separation would be a sad loss for you.

Apparently, due to a misunderstanding on my part — that is, Kitt Peak's desire to publish the photos themselves — as well as the wording of my letter to respondents and the July 1975 Publisher's Memo, some of the scientists and staff of Kitt Peak expressed disappointment and were offended.

With great haste I wish to point out that at no time had my intention been to offend anyone at Kitt Peak. We at ASTRONOMY value too highly the rapport we share with their spokesman, David Moore, and with each of the scientists and staff that comprise Kitt Peak National Observatory, to intentionally or maliciously set out to diminish the good name of an organization we hold in such high regard.

It is for this reason, Kitt Peak National Observatory, our good friend, that I personally, with heartfelt sincerity apologize for any slight you may have perceived in my handling of this matter. I assure you, none was intended, and we eagerly desire your continued friendship and good will.

To our readers whose attitude toward Kitt Peak may have "cooled": In view of this letter, please re-examine your opinion if the manner in which this matter was handled in any way clouded Kitt Peak's good name in your mind.

Stephen A. Walther

Stephen A. Walther
Publisher

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

September 1975 Vol. 3, No. 9

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Cover

This month's cover illustrates one possible explanation for the mysterious behavior of quasars — tiny, quickly moving sources of intense light and radio energy. Like an intergalactic missile from science fiction, the quasar blasts out of a galaxy's nucleus at an extremely high acceleration. Proponents of this theory argue most quasars appear along our line of sight, relatively close to spiral galaxies. In this issue, Donald Goldsmith investigates current explanations for quasars. Artwork by Adolf Schaller.

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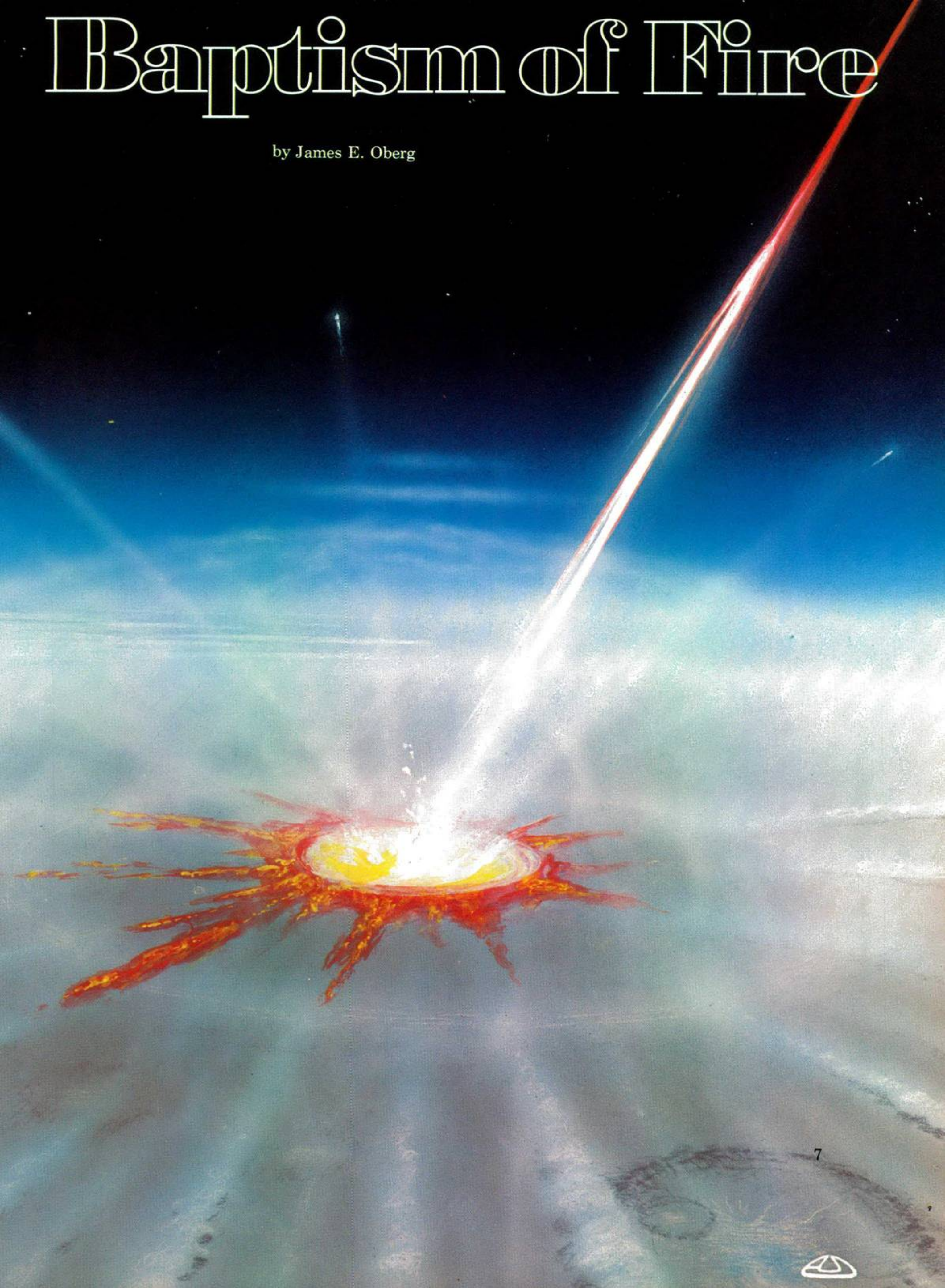
Baptism of Fire

by James E. Oberg



Several billion years ago, the solar system was a cosmic shooting gallery. In their solar orbits, the newborn planets gravitationally swept up debris left over from creation.

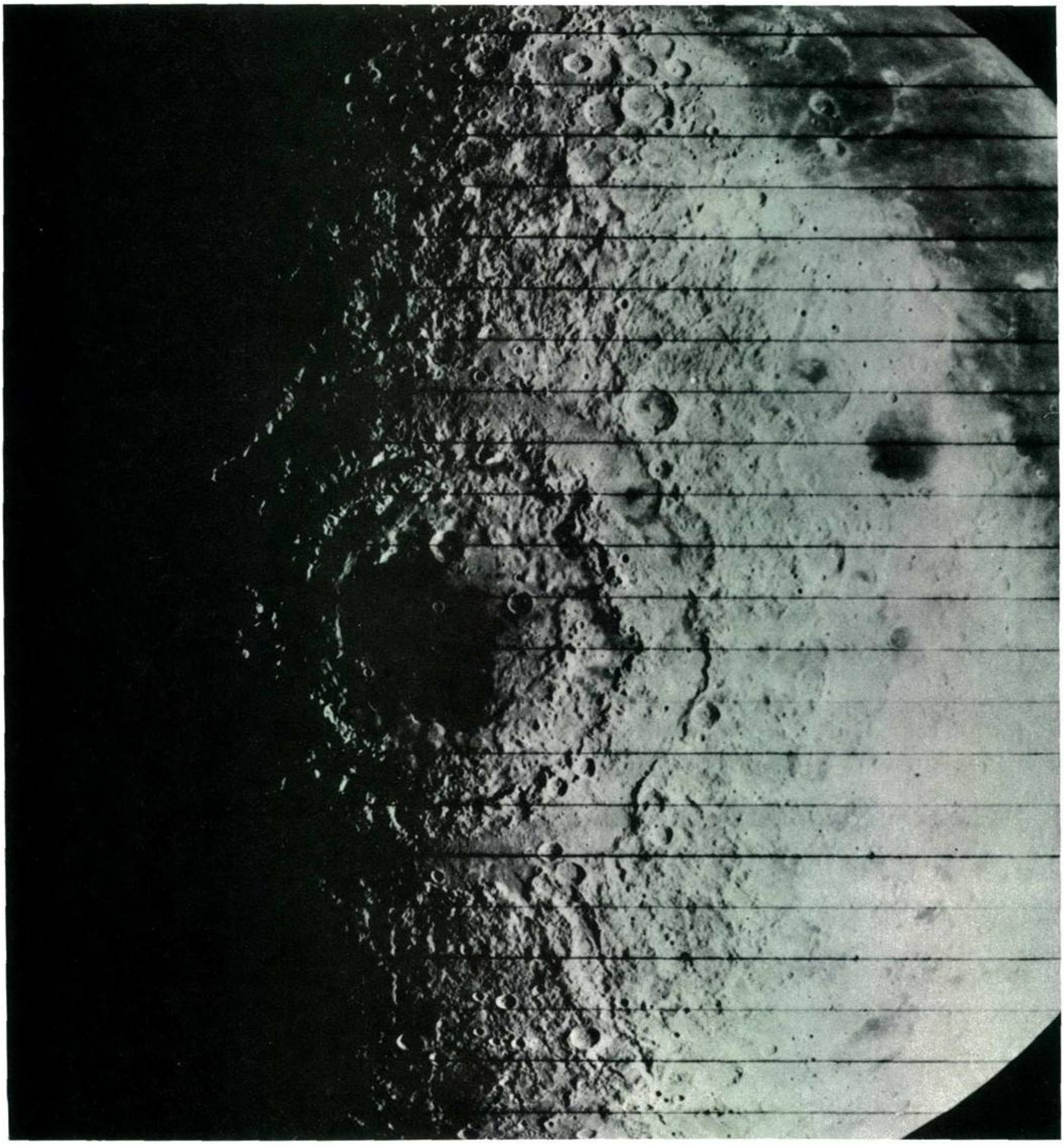
Through telescopes or with robot television cameras, the surfaces of neighboring planets bear the scars of ancient bombardment. Meteor craters and lava flows cover the faces of the moon, Mars, Mercury and smaller bodies. Even Venus, as radar scans indicate, is strewn with traces of meteoric impacts.

Then one's eyes turn toward Earth — the blue space oasis, with its oceans and gentle landscapes. Surely Earth was also subject to the same celestial bombardment which forever scarred the other planets. Where are the traces of such craters?

While the moon was receiving most of its scars several billion years ago, Earth's surface was still

Caption for page 6

An asteroid collides with Earth one billion years after its formation. The impact force, equal to more than a million million tons of TNT, tears through Earth's crust halfway down to the mantle. Lava wells up at the impact site to eventually crystallize in the fresh crater. Although this crater initially rivaled any of the large impact features on the moon, eons of weathering and erosion have erased most of its structure. Finding the remnants of these primordial blasts presents a challenge for today's geologists. Artwork by Adolf Schaller.

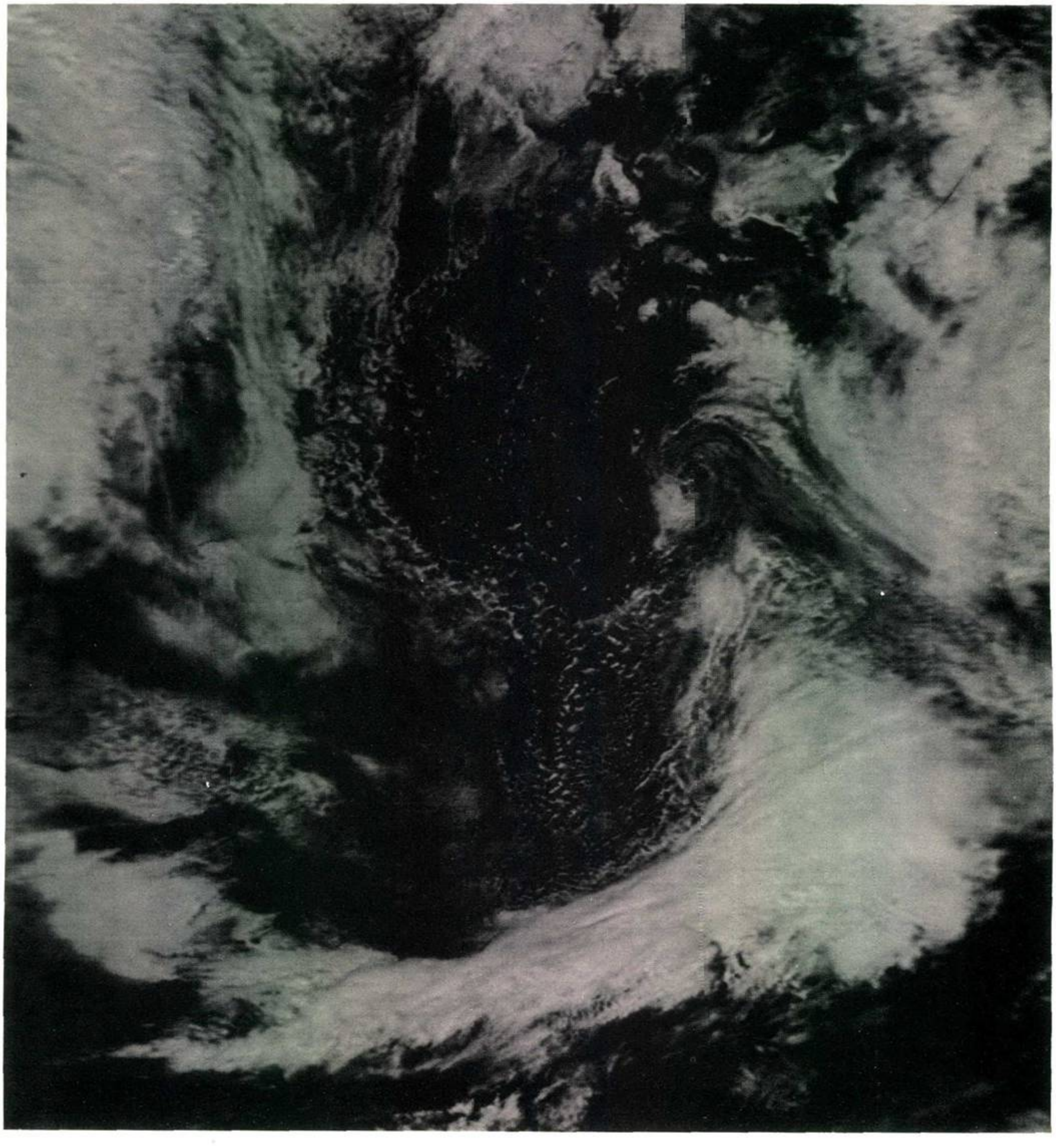


molten. By the time Earth's crust began to cool and harden (about three billion years ago), most of the meteor impacts had subsided. More than a hundred lunar craters remain, however, dating from since that time. These pits spread across an area equivalent to North America, and include such notable features as Copernicus, Tycho and Tsiolkovsky. They must have "contemporaries" on Earth. How can they be found and identified?

In searching for ancient craters, geologists must consider the fact that Earth has a much different environment than the moon. Earth's dynamic forces, including weathering and crustal movement, are slowly erasing primordial craters. So, although experts are convinced that Earth had craters rivaling the moon's major impacts, finding them has been a fascinating problem confronting modern geology.

Experts first take into account the fact that

The moon's Mare Orientale (left) is the most dramatic record of an asteroid sized impact yet observed. Mountains ringing this 600 mile diameter basin rise 20,000 feet above the terrain. Some geologists suggest that Hudson Bay (right) may be Earth's equivalent of a Mare Orientale type impact. The bay's eastern edge resembles the rim of a crater. However, if any central peak exists, it is now buried under sediment at the lake's bottom. NASA photograph.



craters form differently on Earth than on the moon. Our planet's greater gravity restricts the size of the hole resulting from an impact. Calculations show that a body hitting Earth would form a crater only 1/8 the volume (half the diameter) of a crater on the moon. This is true even though a crater is almost totally created not by material ejected from it (*spallation*), but by material pushed into the ground (*compression*).

The atmosphere, although providing a spectacular end to smaller scraps of space debris, plays little part in larger encounters. A really large meteor would not be slowed much during the few seconds of passage through air — even though the high deceleration loads might cause medium sized bodies to break apart. (Most recent craters like the Barringer crater in Arizona seem to be part of multiple impacts spreading from a parent body which entered the atmosphere at an angle and fragmented a few seconds prior to hitting the ground.) Something a few hundred feet or more in diameter would not even notice the resistence.

As the asteroid body hits the ground, the tremendous energy of its momentum is transferred to the surface. A flash of light flares while kinetic energy piles up and is released into the ground below the impact. The meteor body disintegrates with the impact and the heat, and tremendous shock waves compress the rock in all directions. Above, fragments fly out into the air. Below, the compressed rock may rebound — freezing into the characteristic central peak of medium sized lunar craters. The shock waves in air and rock soon degenerate into sonic booms and eventually die out. Rock from the crater's rim falls back into the pit, forming a collection of fused rubble.

Once formed, the crater and surviving meteor fragments not vaporized on impact are subject to all the slow but persistent erosion of a previously powerless environment. Wind and water level the walls and fill the pits. If submerged in a shallow sea, the crater is covered with layers of sediment which eventually turn to stone. Crustal folding and buckling over hundreds of millions of years distort the shape, direction and horizontal orientation of the original formation. Nothing visible remains on the surface.

The only traces on Earth of meteor craters more than a few hundred million years old would be their effects on minerals composing the original crater. These would be extremely shattered and jumbled with the rocks showing traces of shock metamorphism — a process altering their internal crystalline structure.

At shock overpressures of a million atmospheres (15,000,000 pounds per square inch), the rocks would completely melt and later resolidify. Below that, minerals would be transformed into new forms similar to the original (like diamonds are similar to their parent stone, coal). But a unique structure, formed at such lower overpressures as 20,000 to 100,000 atmospheres (in geologic terms, 20 to 100 kilobars), is part of a fascinating story in contemporary geology — a story which has profound implications for future planetary explorations. The structure is called a *shatter cone*.

When a bullet hits a plane of glass, a small cone shaped plug often pops out. The apex of the cone points toward the direction from which the shock came. In stone, a shock wave moving through the substance can cause the same effect when it encounters a pebble or other piece of foreign matter. The type of mineral does not seem to matter; in all kinds of stone, the apex still points towards the point of shock origin.

The main questions facing classical geologists deal with finding natural causes capable of generating shock levels required to form these shatter cones. At various times, local terrestrial events such as volcanic eruptions, steam explosions, or lightning impacts were proposed as explanations for such formations. They were called *cryptovolcanic* structures since they existed without any trace of the volcanic forces which were assumed to have caused them.

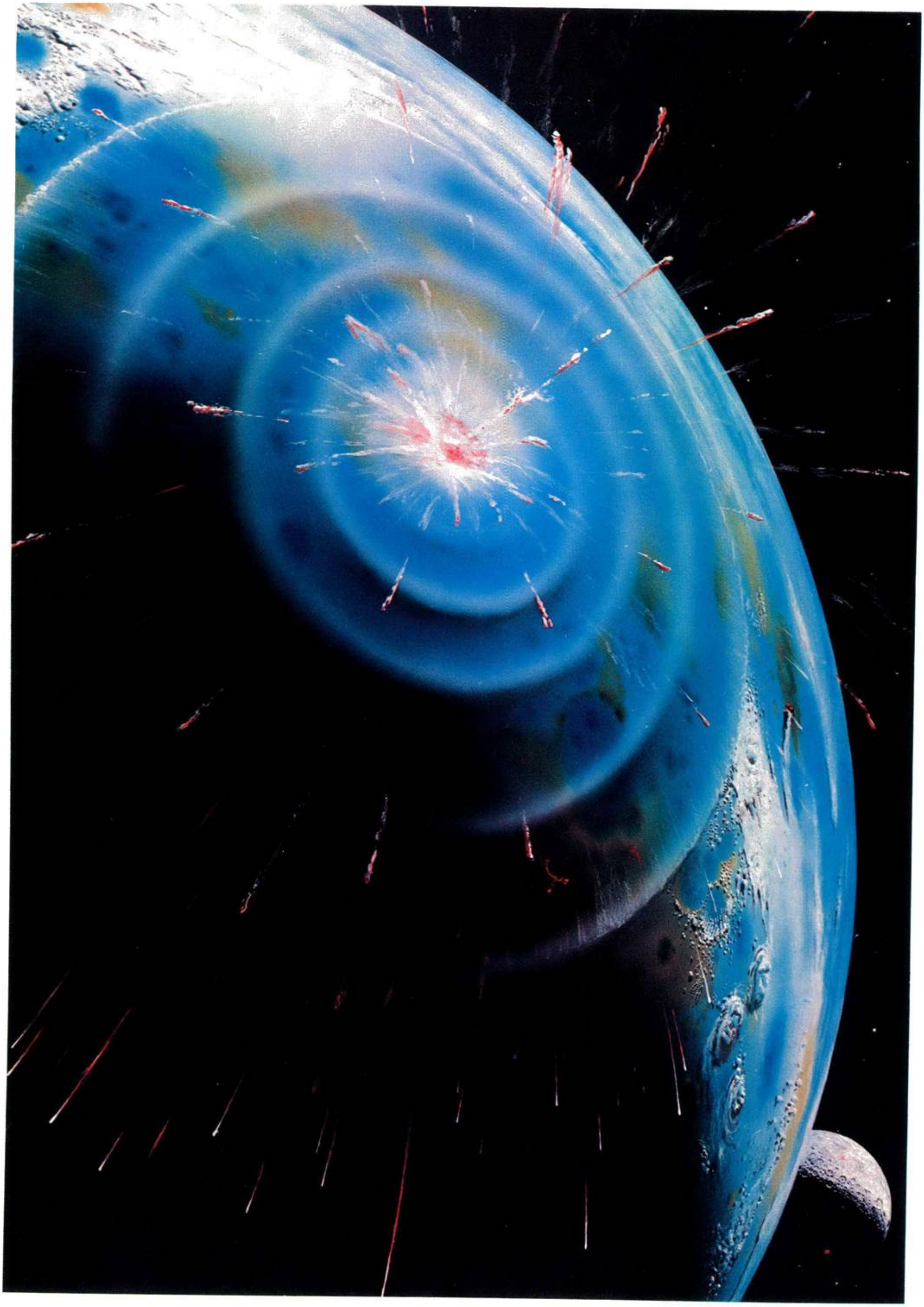
But experiments indicated that the required blast effects were far greater than possible with any such *endogenous* (interior generated) phenomena. For almost three decades, a growing school of geologists has insisted shatter cones are clear evidence (often the only surviving evidence) of a massive *exogenous* (outside generated) event such as a meteor impact. This theory, first formulated by geologist Robert Dietz in 1947, has been widely accepted only in the past few years.

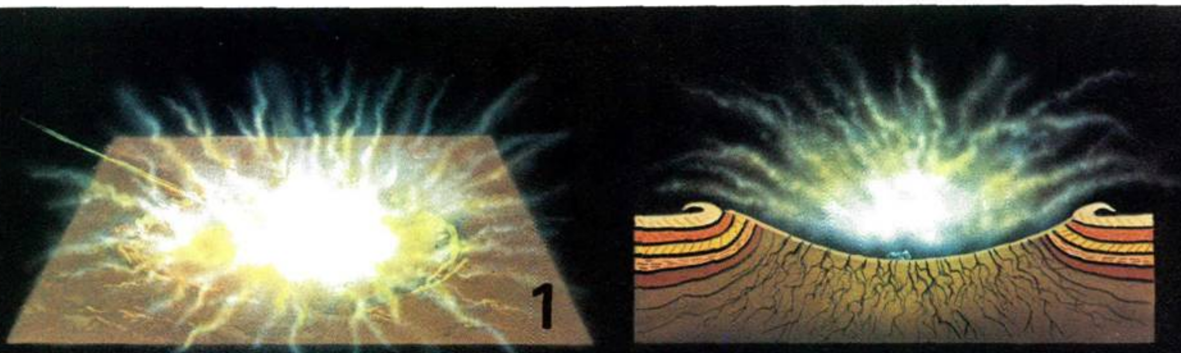
The clinching proof for this line of thought was based on geologic research which found shatter cones associated with a dozen structures already accepted as meteoric craters on other grounds, while shatter cones have never been found in other non-meteoric structures such as volcanos.

The acceptance of the shatter cone theory did not take place until after the Apollo landings, so astronauts did not begin looking for them until the flight of Apollo 16. They found them. It is safe to say that such structures will be found and examined by geologist-astronauts on all the other solid bodies in the solar system as well.

Surveys have now been completed on many of Earth's oldest regions — such as the ancient Canadian shield and the similarly ancient Scandinavian shield. Most craters larger than 20 miles in diameter have probably been identified, their numbers and

An asteroid impacts a shallow continental sea on primitive Earth. Rock and millions of gallons of water fling into the upper atmosphere and near-space, as shock waves expand outward to encircle the planet. Such an event likely occurred three billion years ago in what is now Ontario, Canada. Fortunately the only life on Earth consisted of single-celled ocean life. Artwork by Adolf Schaller.





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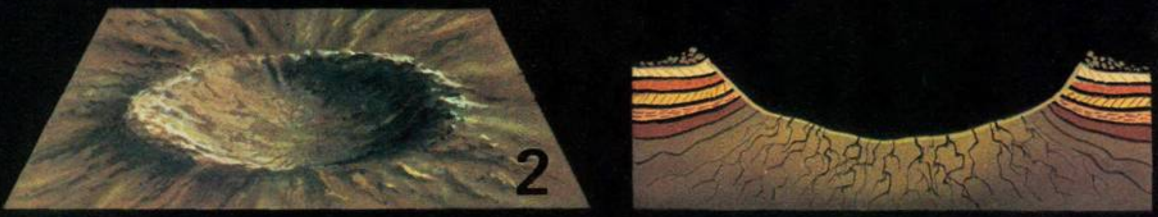

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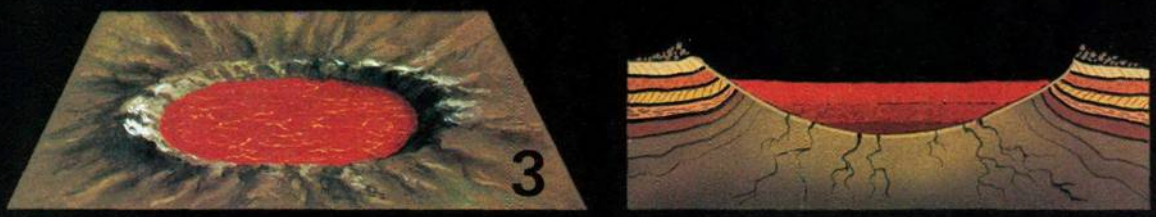

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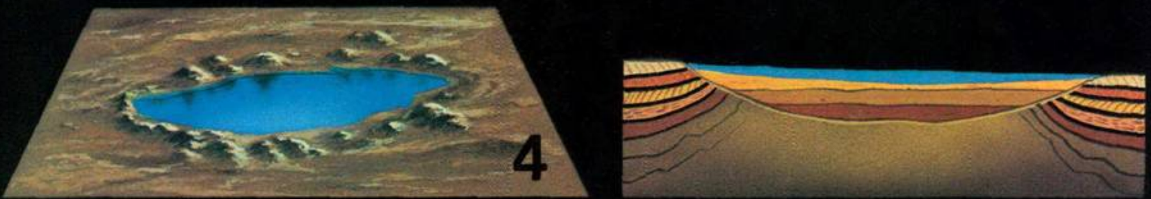

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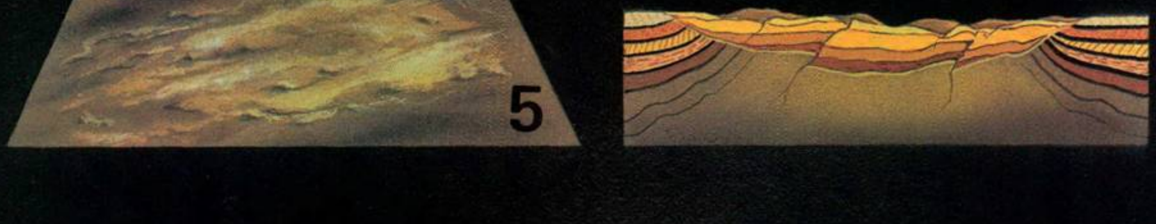

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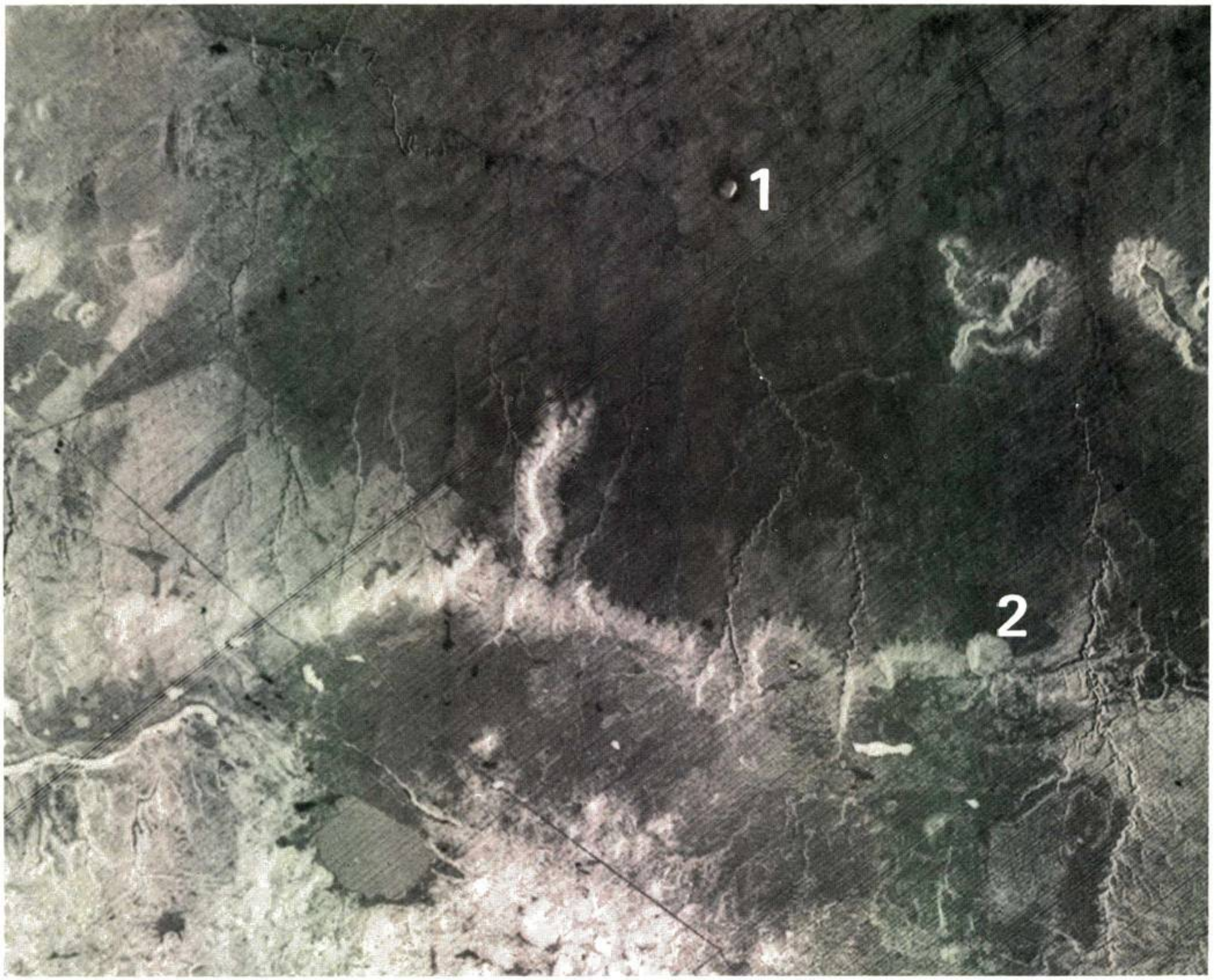


Satellite photography of Earth allows scientists to hunt for circular impact structures, and practice distinguishing between those formed by meteorites and terrestrial events. For example, in this view near Flagstaff, Ariz. a meteor crater (1) prominently appears (a surprising discovery is the existence of raylike features). A nearby butte (2) deceptively resembles a crater structure in this two-dimensional perspective. Volcanic cinder cones also produce a cratering effect in the Sunset Crater Field. In examining the orbital photos, experts are surprised at the lack of new impact structures. NASA photograph.

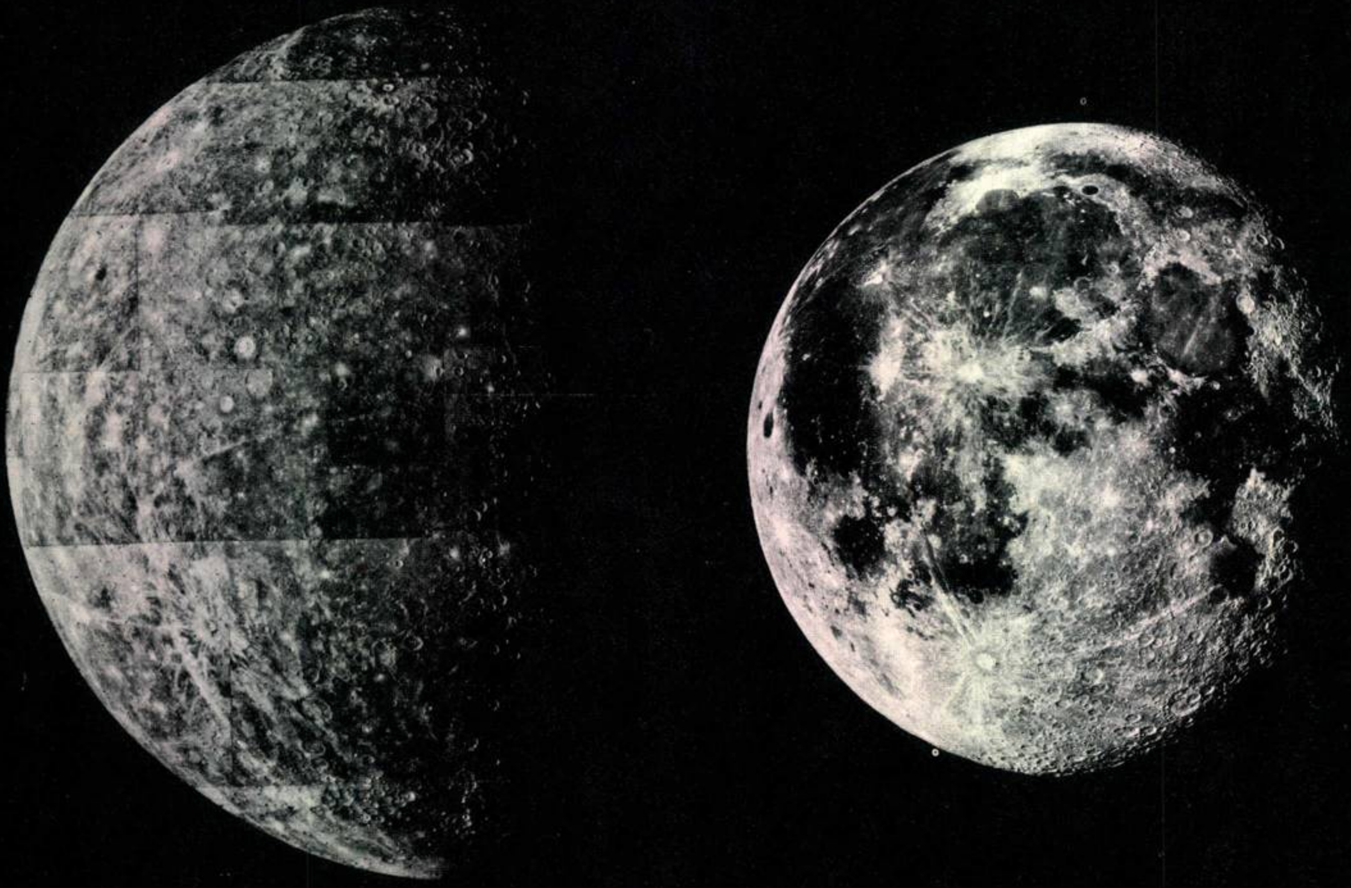
ages agreeing well with observed lunar cratering rates. One of the largest of these structures has been known to geologists for more than a century, although its meteoric parenthood was only slowly realized. It is called the Vredefort Ring structure of South Africa — the eroded remains of a crater probably 40 miles across. Isotope dating techniques put its age at 1,970,000,000 years.

No puny space pebble caused this ancient crater; extrapolating from tests on nuclear explosives, specialists have estimated the crater was caused by an asteroid larger than one mile in diameter, impacting at a speed greater than 12 miles per second. The resulting explosion had a force between 2 and 50 million megatons (the largest H-bomb ever built had an explosive force of 100 megatons). Earthquakes exceeding anything possible from internal stress in the terrestrial crust were generated. Shock waves and air blasts circled Earth, wiping clean in the African region like an apple on a sleeve. Debris thrown into space and into the atmosphere could have precipitated a temporary planetwide ice age lasting a few centuries.

Rock layers tens of miles thick were peeled back like a thrown-aside blanket, opening a hole in Earth's crust halfway down to the mantle. Blast induced melting and lava welling up from inside Earth quickly filled the giant cavity.

The only life on Earth after this cataclysm consisted of single-celled plants in the oceans. Presumably this was the highest life which had evolved

This sequence depicts the evolution of a major impact feature on Earth, the Sudbury structure in Ontario, Canada. Energy from the initial impact (1) peels back rock strata, forming a crater (2). Magma wells up in the crater (3) creating a saucer shaped pool. Water (4) eventually fills the basin and deposits sediments. Crustal movement and erosion continue to deform and bevel the site (5). Artwork by Victor Costanzo.



Crater-scarred surfaces are the rule rather than the exception among planets of the inner solar system. Billions of years of meteor bombardment are etched across the faces of Mercury, Mars and the moon. Recent radar mapping of cloud-covered Venus (not shown here) also suggests cratering. Billions of years ago, Earth must have experienced a similar amount of impacting. But only Earth, through weathering and geologic activity, has erased much evidence of that early era. NASA photographs.

at this point; probably any higher life forms which might have existed would have been destroyed.

Today nothing visible remains of this crater. But its traces are found in shattered strata and the evidence of melted rocks. Ancient crater specialist Dietz has suggested the term *astrobleme* (or *star wound*) for the remnants of such titanic explosions.

This was not the only such impact. An even larger crater was formed at about the same geologic epoch (within a few hundred million years!) in North America. This crater, known as the Sudbury structure in Ontario, Canada, had an explosive force far greater than that of the Vredefort event. Again, magmatism and lava flow were triggered when the asteroid smashed into a shallow continental sea two billion years ago.

At that time, Earth would have seemed another world. The land was lifeless, covered with ash, rain-washed rubble and the beginnings of eroded soils and sands. The atmosphere had no free oxygen or nitrogen since plants were still developing in the oceans. The continents hardly resembled their future shapes. The so-called Pangea continent, parent of today's land masses, did not even form until 1-1/2 billion years after the great asteroid impacts.

But even then the world was mostly covered with the deep oceans. If these two catastrophes occurred on the continents, how many more such asteroids fell into those oceans? No crater would form on the sea bottom, but hydrodynamic studies suggest that such a million megaton event would empty the water from an ocean basin, forming waves two miles high which would overwhelm neighboring continents. This must have happened many times.

Paleontologists know that life did not achieve a foothold on land until 300 million years ago, after

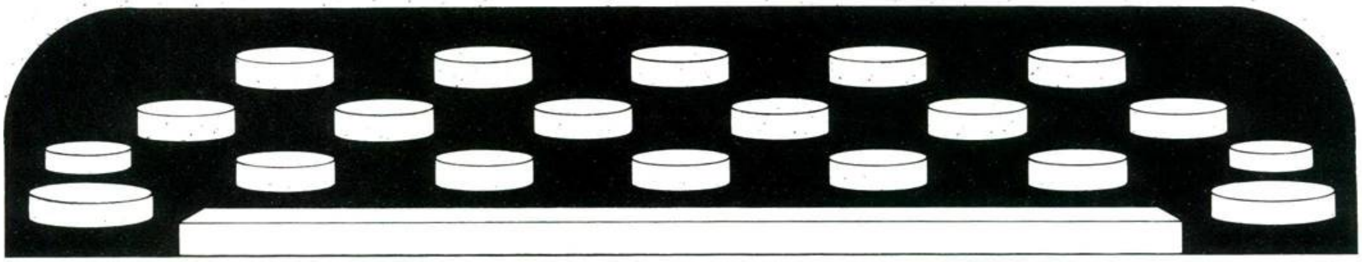
more than two billion years in the oceans. They had always presumed it was the slow development of evolution, and were unaware a cosmic process might be repeatedly wiping out all life forms on land.

What about the water in these oceans? The titanic blast of an asteroid impact (splash is too tame a word) might have propelled millions of gallons of sea water into space. On dry land, meteor impacts splashed rock into space to fall back to Earth as tektites. What would be the mutation and evolutionary effects of one-celled plants thrown into space and back? What about the water (now frozen to ice) thrown clear of Earth, to wander through space as Earthborn comets? Do some of today's comets consist of terrestrial sea water, with frozen billion-year-old protozoa still inside?

The search for geologic traces of such devastating events continues. On any map, the east coast of Hudson Bay is remarkably circular; some specialists have suggested that the Hudson Bay Arc is part of the rim of a crater. On-site exploration has revealed the arc is a true geological boundary, but any shatter cones would be found toward the middle of the crater, under water and several thousand feet of postimpact sediments. The case is still open for the "biggest yet" terrestrial crater, rivaling the moon's Mare Orientale in size.

The new field of *comparative planetology* involves disciplines such as meteorology, geochemistry, mineralogy and classical geology. It has recently been revealed one does not have to go to other worlds to study other-worldly structures such as large meteor impacts sites. Much work remains to be done on foot here on Earth, as specialists study the formation and erosion processes varying from planet to planet.

The arrival of the space age allows mankind to study the phenomenon of meteor impacts from space. Within a few decades, spacefaring patrol ships will let men gain the power to insure that such craters as Vredefort and Sudbury never happen again. The tender Earth will no longer be a target for celestial bombardment.



IN FOCUS

This month's installment of In Focus ends a three month forum of comments, replies and rebuttals generated by "The Zeta Reticuli Incident" which appeared in ASTRONOMY*'s December 1974 issue. The following reply to Carl Sagan and Steven Soter by Michael Peck had been scheduled for the August issue, to appear with a reply to Sagan and Soter by David Saunders. Space limitations did not allow both replies to appear in that issue. Therefore, Peck's reply appears this month along with a reply by Sagan and Soter to both Saunders and Peck.*
Stephen A. Walther, Publisher

To Steven Soter and Carl Sagan:

by

Michael Peck

Carl Sagan and Steven Soter, in challenging the possibilities discussed in "The Zeta Reticuli Incident", suggest that without the connecting lines drawn into the Hill map and the Fish interpretation there is little resemblance between the two. This statement can be tested using only X and Y coordinates of the points in the Hill map and a projection of the stars in the Fish pattern. The method used for the comparison can be visualized this way:

Suppose points of the Hill map and the Fish map are plotted on separate glass plates. These plates are held parallel (one behind the other), and are moved back and forth and rotated until the patterns appear as nearly as possible to match. A systematic way of comparing the patterns would be to adjust the plates until corresponding pairs of points match exactly. Then the other points in the patterns can be compared. Repeating this process for all the possible pairs of points (there are 105 in this case), the best fit can be found. Mathematically, this involves a change of scale and a simple coordinate transformation. A computer program was written which, using X and Y coordinates measured from a copy of the Hill map and a projection of the Fish stars, and using the Hill map as the standard, computed new X and Y coordinates for the Fish stars using the process described. From these two sets of coordinates, six quantities were calculated: the average difference in X and Y; the standard deviation of the differences in X and Y, a measure of the amount of variation of the differences; and correlation coefficients in X and Y. The coefficient of correlation is a quantity used by statisticians to test a suspected relation between two sets of data. In this case, for instance, we suspect that the X and Y coordinates computed from the Fish map should equal the X and Y coordinates of the Hill map. If they matched exactly, the correlation coefficients would be one. If there were no correlation at all, the value would be near zero. We found that, for the best fitting orientation of the Fish stars, there was a correlation coefficient in X of 0.95 and in Y of 0.91. In addition, the average difference and the standard deviation of the differences were both small — about 1/10 the total range in X and Y. As a comparison, the same program was run for a set of random points, with resulting correlation coefficients of 1/10 or less (as was expected). We can conclude, therefore, that the degree of resemblance between the two maps is fairly high.

From another point of view, it is possible to compute the probability that a random set of points will coincide with the Hill map to the degree of accuracy observed here. The probability that 15 points chosen at random will fall on the points of the Hill map within an error range which would make them as close as the Fish map is about one chance in 10^{15} (one million billion). It is 1,000 times more probable that a person could predict a bridge hand dealt from a fair deck.

Michael Peck is an astronomy student at Northwestern University in Illinois.

To David Saunders and Michael Peck:

by

Steven Soter and Carl Sagan

Dr. David Saunders last month claimed to have demonstrated the statistical significance of the Hill map, which was allegedly found on board a landed UFO and supposedly depicted the sun and 14 nearby sunlike stars. The Hill map was said to resemble the Fish map — the latter being an optimal two-dimensional projection of a three-dimensional model prepared by selecting 14 stars from a positional list of the 46 nearest known sunlike stars. Saunders' argument can be expressed by the equation $SS = DR - (SF + VP)$, in which all quantities are in information bits. SS is the statistical significance of the correlation between the two maps, DR is the degree of resemblance between them, SF is a selection factor depending on the number of stars chosen and the size of the list, and VP is the information content provided by a free choice in three dimensions of the vantage point for projecting the map. Saunders finds $SS = 6$ to 11 bits, meaning that the correlation is equivalent to between 6 and 11 consecutive heads in a coin toss and therefore probably not accidental. The procedure is acceptable in principle, but the result depends entirely on how the quantities on the right-hand side of the equation were chosen.

For the degree of resemblance between the two maps, Saunders claims that DR = 11 to 16 bits, which he admits is only a guess — but we will let it stand. For the selection factor, he at first takes $SF = \log_2 C = 37.8$ bits, where C represents the combinations of 46 things taken 14 at a time. Realizing that the size of this factor alone will cause SS to be negative and wipe out his argument, he makes a number of *ad hoc* adjustments based essentially on his interpretation of the internal logic of the Hill map, and SF somehow gets reduced to only 3.9 bits. For the present, we will let even that stand in order to avoid becoming embroiled in a discussion of how an explorer from the star Zeta Reticuli would choose to arrange his/her/its travel itinerary — a matter about which we can claim no particular knowledge. However, we must bear in mind that a truly unprejudiced examination of the data with no *a priori* interpretations would give SF = 37.8 bits.

It is Saunders' choice of the vantage point factor VP with which we must take strongest issue, for this is a matter of geometry and simple pattern recognition. Saunders assumes that free choice of the vantage point for viewing a three-dimensional model of 15 stars is worth only VP = 3 bits. He then reduces the information content of directionality to one bit by introducing the "constraint" that the star Zeta Tucanae be occulted by Zeta Reticuli (with no special notation on the Hill map to mark this peculiarity). This *ad hoc* device is invoked to explain the absence of Zeta Tucanae from the Hill map, but it reveals the circular reasoning involved. After all, why bother to calculate the statistical significance of the supposed map correlation if one has already decided which points represent which stars?

Certainly the selection of vantage point is worth more than three bits (not to mention one bit). Probably the easiest circumstance to recognize and remember about random projections of the model in question are the cases in which two stars appear to be immediately adjacent. By viewing the model from all possible directions, there are 14 distinct ways in which *any given star* can be seen in projection as adjacent to some other star. This can be done for *each* of the 15 stars, giving 210 projected configurations — each of which would be recognized as substantially different from the others in information content. And of course there are many additional distinct recognizable projections of the 15 stars not involving any two being immediately adjacent. (For example, three stars nearly equidistant in a straight line are easily recognized, as in Orion's belt.) Thus for a very conservative lower bound, the information content determined by choice of vantage point (that is, by being allowed to rotate the model about three axes) can be taken as at least equal to $VP = \log_2(210) = 7.7$ bits. Using the rest of Saunders' analysis, this would at best yield SS = zero to 4.4 bits — not a very impressive correlation.

There is another way to understand the large number of bits involved in the choice of the vantage point. The stars in question are separated by distances of order 10 parsecs. If the vantage point is situated above or not too far from the 15 stars, it need only be shifted by about 0.17 parsecs to cause a change of one degree in the angle subtended by some pair of stars. Now one degree is a very modest resolution, corresponding to twice the full moon and is easily detected by anyone. For three degrees of freedom, the number of vantage points corresponding to this resolution is of order $(10/0.17)^3 \approx (60)^3 \approx 2 \times 10^5$, corresponding to VP = 17.6 bits. This factor alone is sufficient to make SS negative, and to wipe out any validity to the supposed correlation.

Even if we were to accept Saunders' claim that SS = 6 to 11 bits (which we obviously do not, particularly in view of the proper value for SF), it is not at all clear that this would be statistically significant because we are not told how many other possible correlations were tried and failed before the Fish map was devised. For comparison, there is the well-known correlation between the incidence of Andean earthquakes and oppositions of the planet Uranus. It is unlikely in the extreme that there is a physical causal mechanism operating here — among other reasons, because there is no correlation with oppositions of Jupiter, Saturn or Neptune. But to have found such a correlation the investigator must have sought a wide variety of correlations of seismic events in many parts of the world with oppositions and conjunctions of many astronomical objects. If enough correlations are sought, statistics requires that eventually one will be found, valid to any level of significance that we wish. Before we can determine whether a claimed correlation implies a causal connection, we must convince ourselves that the number of correlations sought has not been so large as to make the claimed correlation meaningless.

This point can be further illustrated by Saunders' example of flipping coins. Suppose we flip a coin once per second for several hours. Now let us consider three cases: two heads in a row, 10 heads in a row, and 40 heads in a row. We would, of course, think there is nothing extraordinary about the first case. Only four attempts at flipping two coins are required to have a reasonable expectation value of two heads in a row. Ten heads in a row, however, will occur only once in every $2^{10} = 1{,}024$ trials, and 40 heads in a row will occur only once every $2^{40} \approx 10^{12}$ trials. At a flip rate of one coin per second, a toss of 10 coins requires 10 seconds; 1,024 trials of 10 coins each requires just under three hours. But 40 heads in a row at the same rate requires 4×10^{13} seconds or a little over a million years. A run of 40 consecutive heads in a few hours of coin tossing would certainly be strong *prima facie* evidence of the ability to control the fall of the coin. Ten heads in a row under the circumstances we have described would provide no convincing evidence at all. It is expected by the law of probability. The Hill map correlation is at best claimed by Saunders to be in the category of 10 heads in a row, but with no clear statement as to the number of unsuccessful trials previously attempted.

Michael Peck finds a high degree of correlation between the Hill map and the Fish map, and thereby also misses the central point of our original criticism: that the stars in the Fish map were already *preselected* in order to maximize that very correlation. Peck finds one chance in 10^{15} that 15 random points will correlate with the Fish map as well as the Hill map does. However, had he *selected* 15 out of a random sample of, say, 46 points in space, and had he simultaneously *selected* the optimal vantage point in three dimensions in order to maximize the resemblance, he could have achieved an apparent correlation comparable to that which he claims between the Hill and Fish maps. Indeed, the statistical fallacy involved in "the enumeration of favorable circumstances" leads necessarily to large, but spurious correlations.

We again conclude that the Zeta Reticuli argument and the entire Hill story do not survive critical scrutiny.

Dr. Steven Soter is a research associate in astronomy and Dr. Carl Sagan is director of the Laboratory for Planetary Studies, both at Cornell University in Ithaca, N.Y.

The Quasar Dilemma

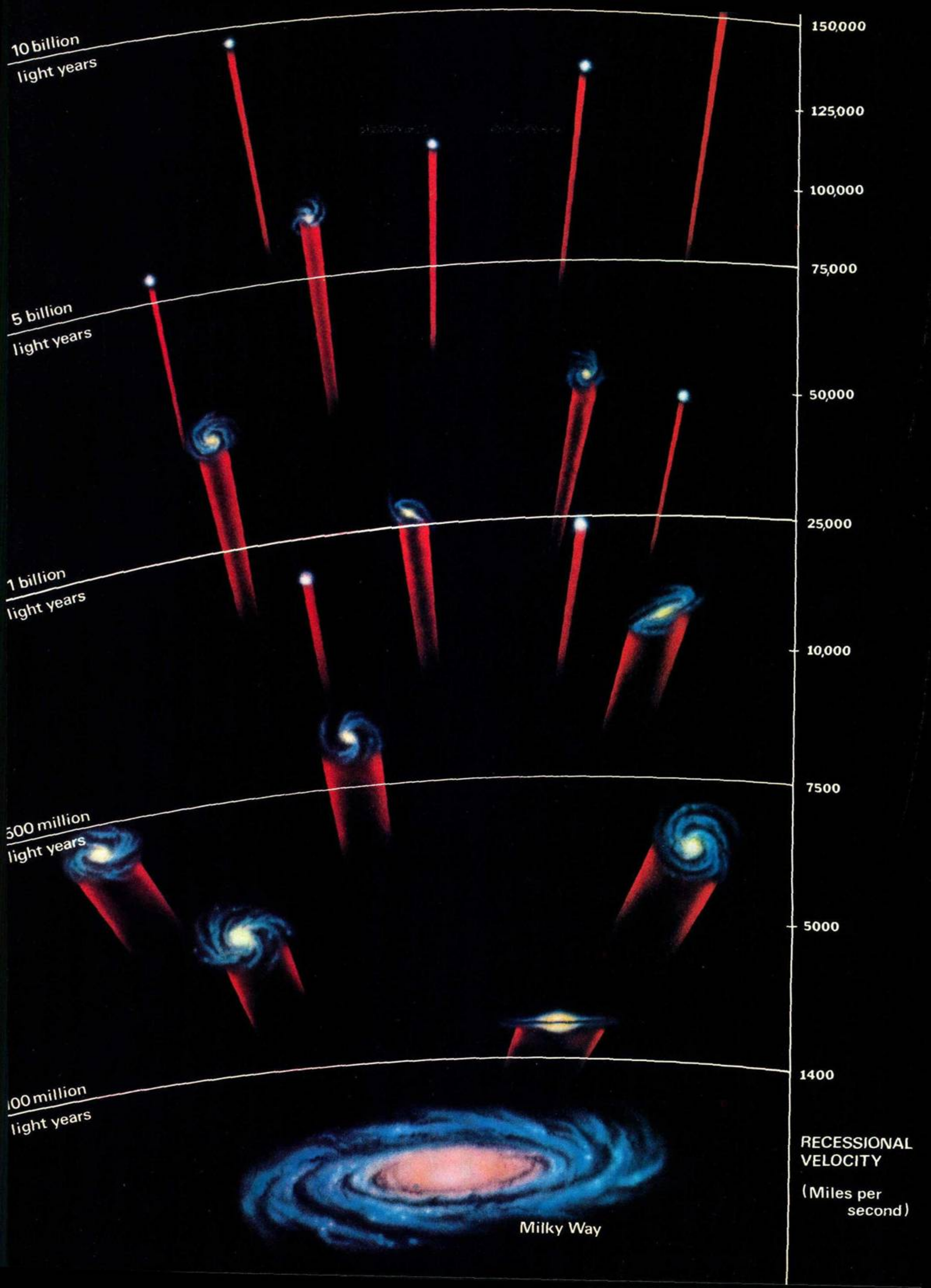
by
Donald Goldsmith

Quasars are either the most distant observable objects in the universe, or else heralds of new laws in physics waiting to be understood. When they were discovered in 1963, quasars stood the world of astronomy on its ear. Astronomers have not yet regained their equilibrium.

Quasars were uncovered by radio surveys of the sky in the 1950s. Some radio sources were supernova remnants — hot shells of gas left over from exploding stars. Others were peculiar galaxies that had undergone some type of explosion during the past few million years. But other sources looked almost exactly like stars. Because ordinary stars do not emit detectable amounts of radio waves, these other pointlike objects had to be something special. Radio astronomers named them *quasi-stellar radio sources* or *quasars.*

What was so special about quasars? Surely not just their starlike appearance — which although

The farther an extragalactic object is from us, the faster it recedes, according to the Hubble law (proposed early this century by astronomer Edwin Hubble). Quasars' tremendous recessional velocities (determined by their spectral redshifts) imply they are the most distant known objects in the universe. Quasars predominate in the billions of light-years range as opposed to millions of light-years for galactic clusters. Because of their great distances, quasars reflect events that occurred in the universe *billions* of years ago. Diagram by Victor Costanzo.


10 billion
light years
5 billion
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1 billion
light years
00 million
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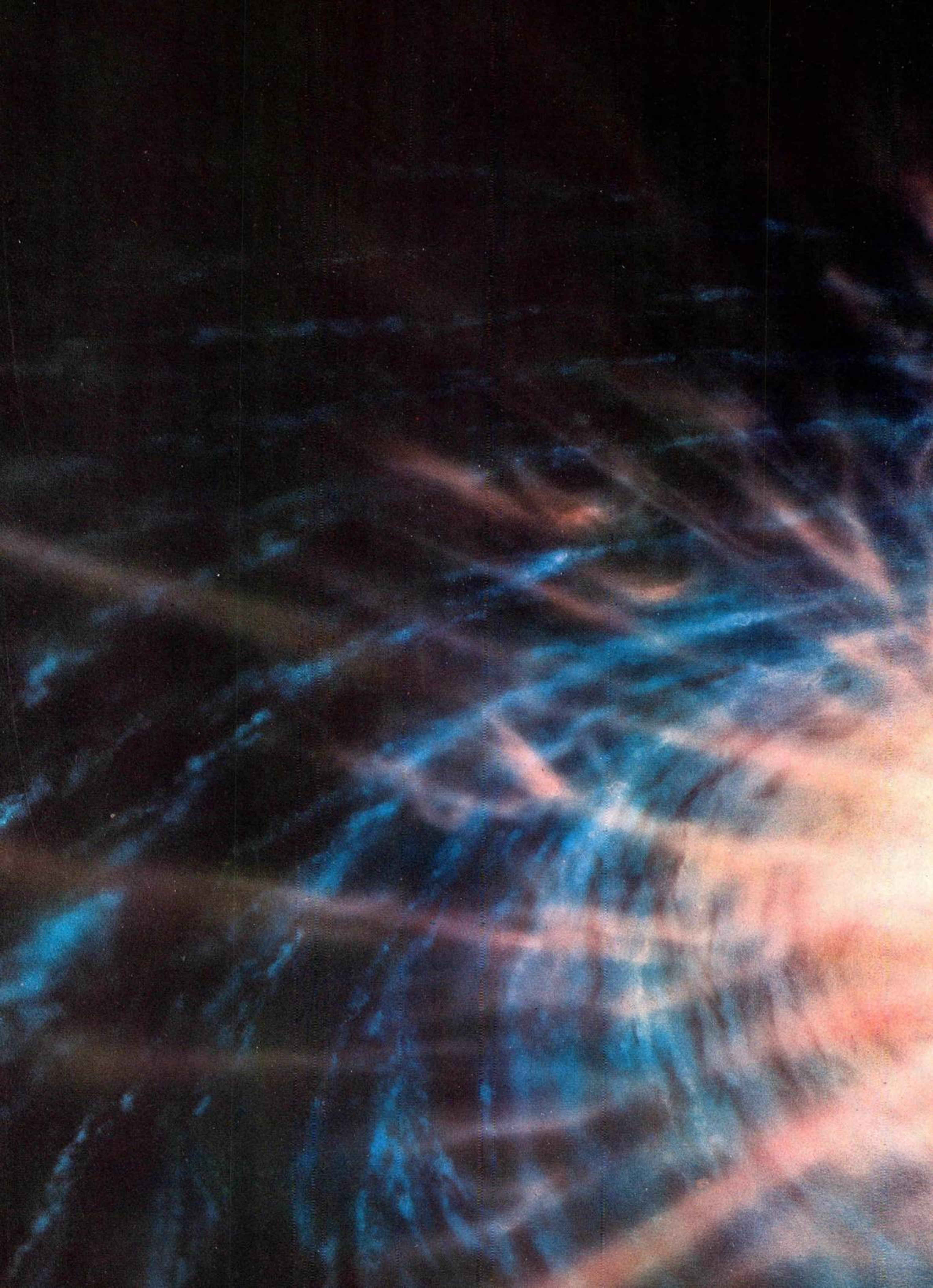
light years
Milky Way
150,000
125,000
100,000
75,000
50,000
25,000
10,000
7500
5000
1400
RECESSIONAL VELOCITY
(Miles per second)



mysterious was hardly unusual. What burst onto the startled consciousness of the astronomical world was the news that quasars have large redshifts in the light they emit.

The *redshift* is a decrease in all the energies of the photons (packets of energy) in light waves. This shift to lower energies reddens light. Photons forming visible light have certain amounts of energy determining their color; red light has the least energy, and blue light the most.

Changes in the energy of all the photons can arise from the so-called *Doppler effect* — which is caused by the motion of a photon source relative to the observer. Photons from a source moving toward us arrive with greater energies than they would have if the source were motionless. Conversely, if a photon source moves away from us (or we move away from the source), the photons will appear to have less energy than they would if the source did not move relative to us. These changes show up as a shift in position of an object's absorption bands within the spectrum. From such changes in energy, astronomers calculate an object's velocity.

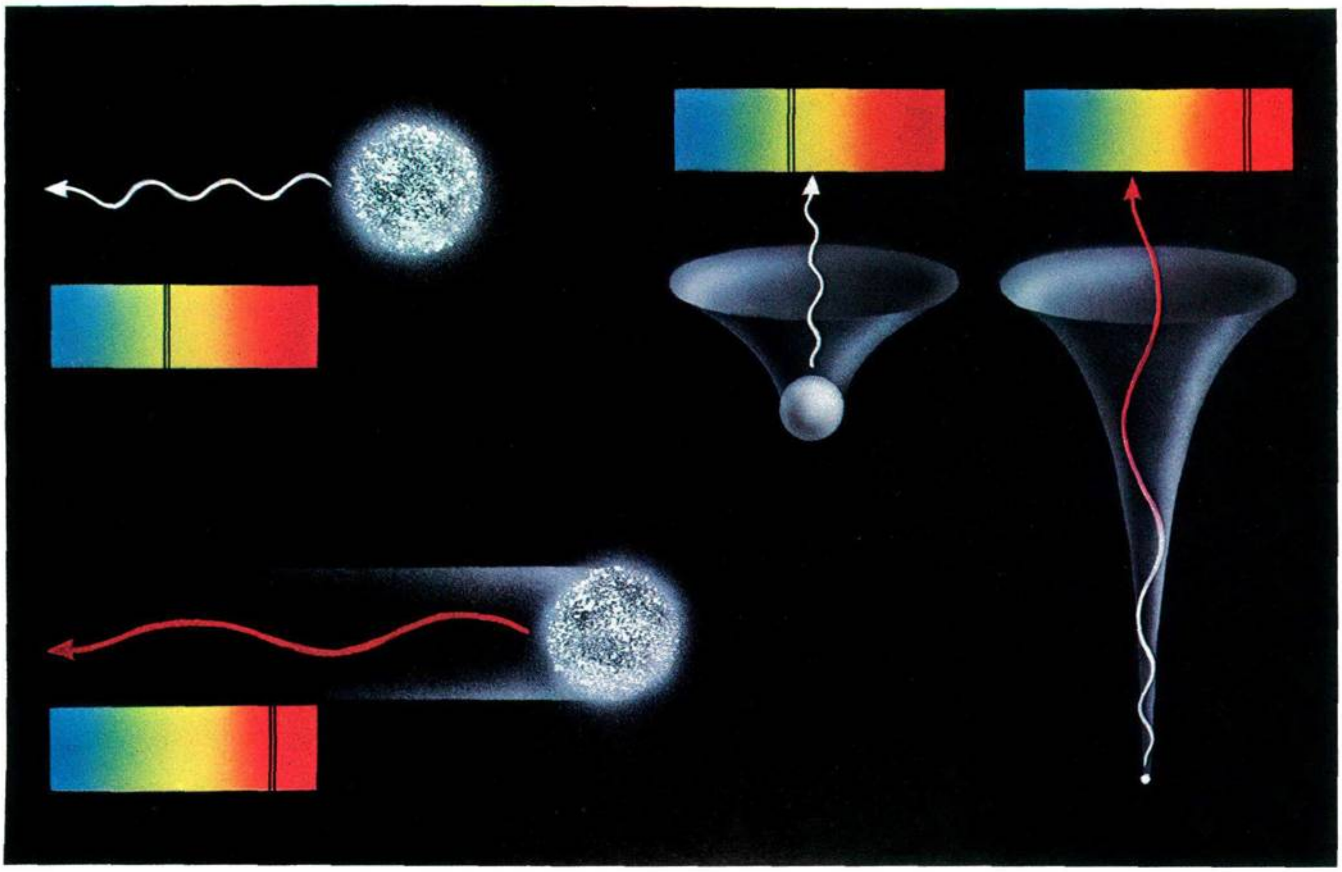
caption for page 20

The nucleus of a distant galaxy glows 1,000 times brighter than normal as hundreds of stars per year erupt in supernovae explosions. Some astronomers suggest such catastrophic events might explain quasars — very distant and bright energy sources. Presently there is no concrete evidence linking quasars to galaxies. Artwork by Adolf Schaller.

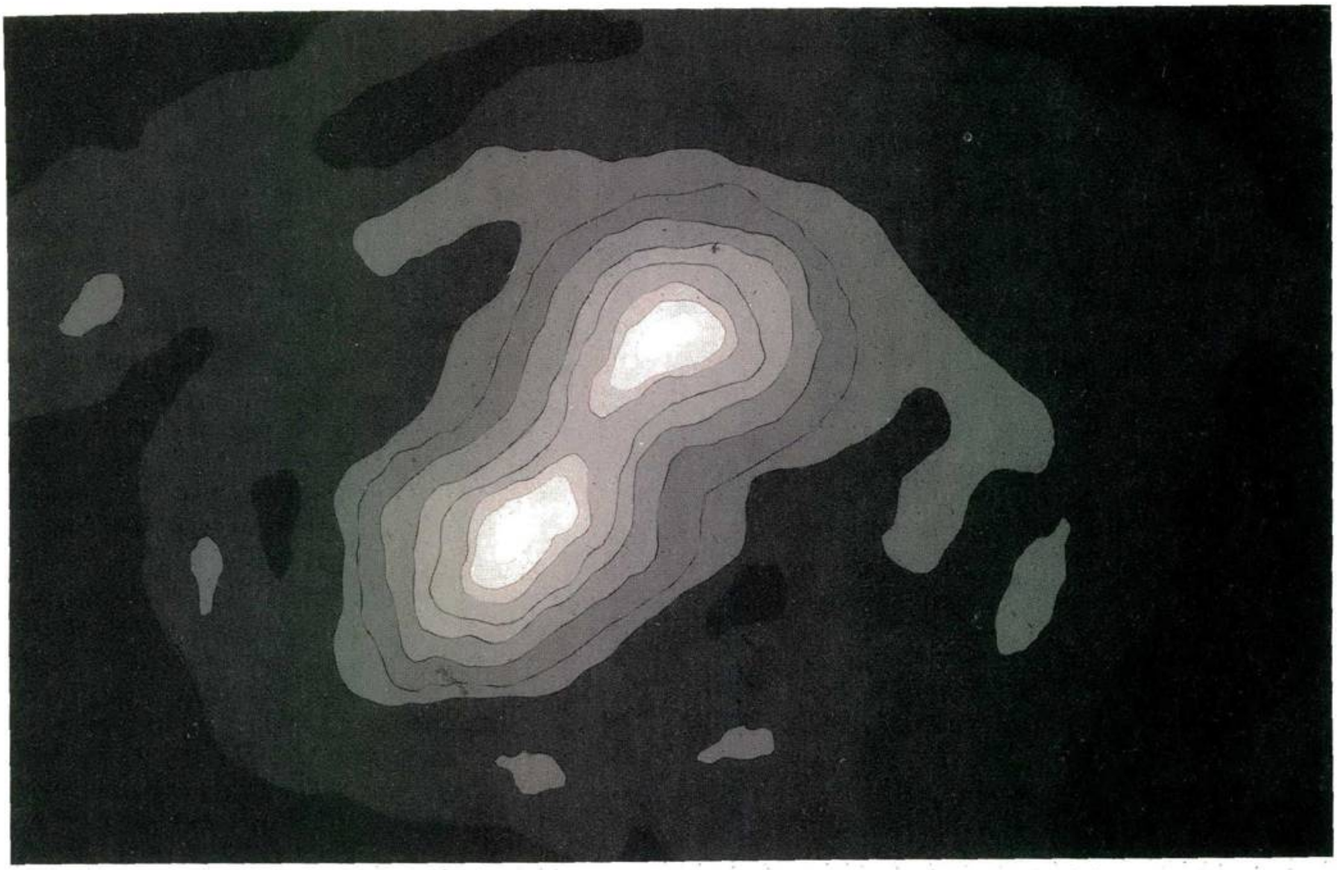
In 1929, astronomer Edwin Hubble discovered that all but the nearest galaxies are moving away from us at velocities proportional to their distances. If we consider our location in the universe as average, then all observers would find a similar pattern. Hubble concluded the entire universe is expanding (see "The Cosmic Bomb", ASTRONOMY, April 1975).

A new generation of astronomers continues verifying *Hubble's law:* Galaxies and galaxy clusters *are* moving away from us, and the faster they move, the farther away they turn out to be. The galaxy cluster with the largest measured Doppler effect is receding from us at almost half the speed of light! If astronomers measure the redshift of a distant galaxy, but *cannot determine* the galaxy's distance immediately, they use Hubble's law to estimate the distance from the galaxy's velocity away from us.

Astronomers were ready to try this approach with quasars. If they could recognize in quasar spectra the usual family of absorption patterns present in stars and galaxies, they could estimate quasar distances by using Hubble's law. However, quasars' light did not resemble any familiar spectra.



Two explanations for the redshifting of an object's spectrum are illustrated above. On the left, redshift occurs due to an object's high recessional velocity. At right, an intense gravitational field also "weakens" or reddens escaping light. Currently many astronomers believe quasar redshifts are produced by high velocities. Only black holes — invisible sources of tremendous gravitation — could cause redshifts as great as those observed in quasars. Diagram by Victor Costanzo.



Optically, quasars appear simply as starlike point sources of light. But a radio image presents a far more dramatic quasar portrait. In this representation of quasar 3C47, two gigantic lobes of radio energy — having centers hundreds of thousands of light-years apart — border the visible region. Artwork by Victor Costanzo.

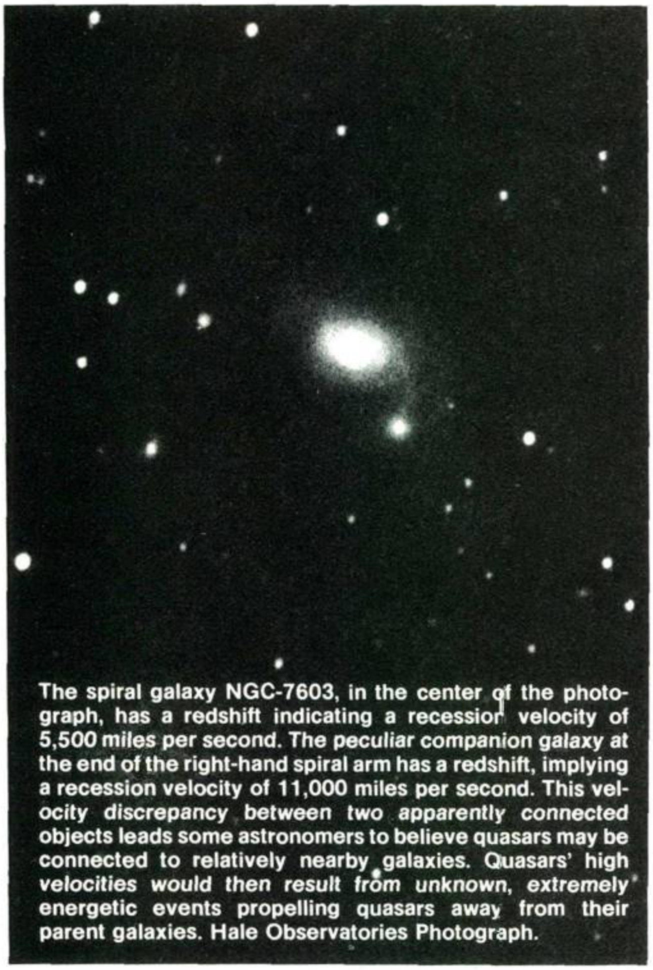
First of all, the quasar spectra prominently showed *extra* photons at certain definite wavelengths — rather than the removal of photons. Second, the energies at which these extra photons appeared did not fall into any familiar pattern. Third, although photons of some energies had been removed, the pattern of these "absorbed" photon energies was also unusual. Finally, quasars were emitting a greater ratio of blue light to red light than ordinary stars do.

In 1963, Caltech astronomers Jesse Greenstein and Maarten Schmidt resolved the mystery of quasar spectra, but also created a host of new problems. Greenstein and Schmidt realized quasar spectra are indeed familiar, but are redshifted beyond any astronomer's expectations. They calculated that particular quasars are receding from us at velocities of 14.5 percent and 30 percent the speed of light, respectively.

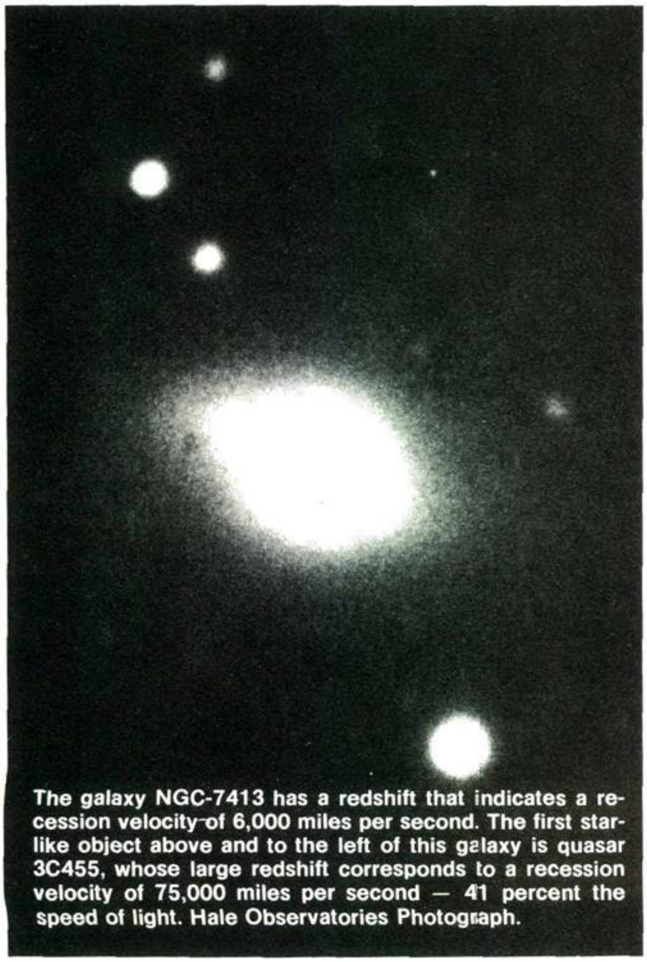
Although these large velocities remain less than the recession velocity of the most distant galaxy cluster, they are surprising speeds for quasars. The problem is that quasars are relatively bright — not bright enough to be seen without a telescope, but brighter than many galaxies we can photograph, and 100 times brighter than the most distant galaxy clusters. The quasars' redshifts put them at distances greater than two billion light-years, at the outer reaches of the visible universe. But the quasars' relatively large apparent brightness means they had to be, by far, the most powerful energy sources known — 10,000 times more powerful than an entire galaxy like our own Milky Way.

Worse contradictions lay in quasar sizes. Even at the enormous distance of two billion light-years, an ordinary galaxy is large enough to appear fuzzy on a good telescopic photograph — while quasars are *quasi-stellar*, (pointlike in appearance.) Thus quasars must be *smaller* than galaxies, even though they outshine them. Still more stringent limits on quasar size comes from the discovery that their light output can vary from one year to the next — and for some quasars even from one *day* to the next. The rapid changes in quasar light output (sometimes doubling in brightness in one day) tells us something about their sizes: *The region producing most of the light cannot be more than one light-day (16 billion miles) across.*

Whatever generates quasar light must occur about the same time, or we would not see such a rapid change in light intensity. If light takes more than a day to cross the quasar's visible region, then even if the change in output were instantaneous, more than a day would elapse before light from all parts of the quasar arrived. A rapid variation in quasar output would be smoothed into a slow, gentle



The spiral galaxy NGC-7603, in the center of the photograph, has a redshift indicating a recession velocity of 5,500 miles per second. The peculiar companion galaxy at the end of the right-hand spiral arm has a redshift, implying a recession velocity of 11,000 miles per second. This velocity discrepancy between two apparently connected objects leads some astronomers to believe quasars may be connected to relatively nearby galaxies. Quasars' high velocities would then result from unknown, extremely energetic events propelling quasars away from their parent galaxies. Hale Observatories Photograph.



The galaxy NGC-7413 has a redshift that indicates a recession velocity of 6,000 miles per second. The first star-like object above and to the left of this galaxy is quasar 3C455, whose large redshift corresponds to a recession velocity of 75,000 miles per second — 41 percent the speed of light. Hale Observatories Photograph.

change. Thus a time scale of one day for the light changes implies a diameter of less than one light-day for the source of quasar light. One light-day equals about twice the size of our solar system and more than 1,000 times *less* than the distance from the sun to the next nearest star in our galaxy! So quasars seem to produce far more energy than our entire galaxy in a diameter *10 million times less* than our galaxy's diameter.

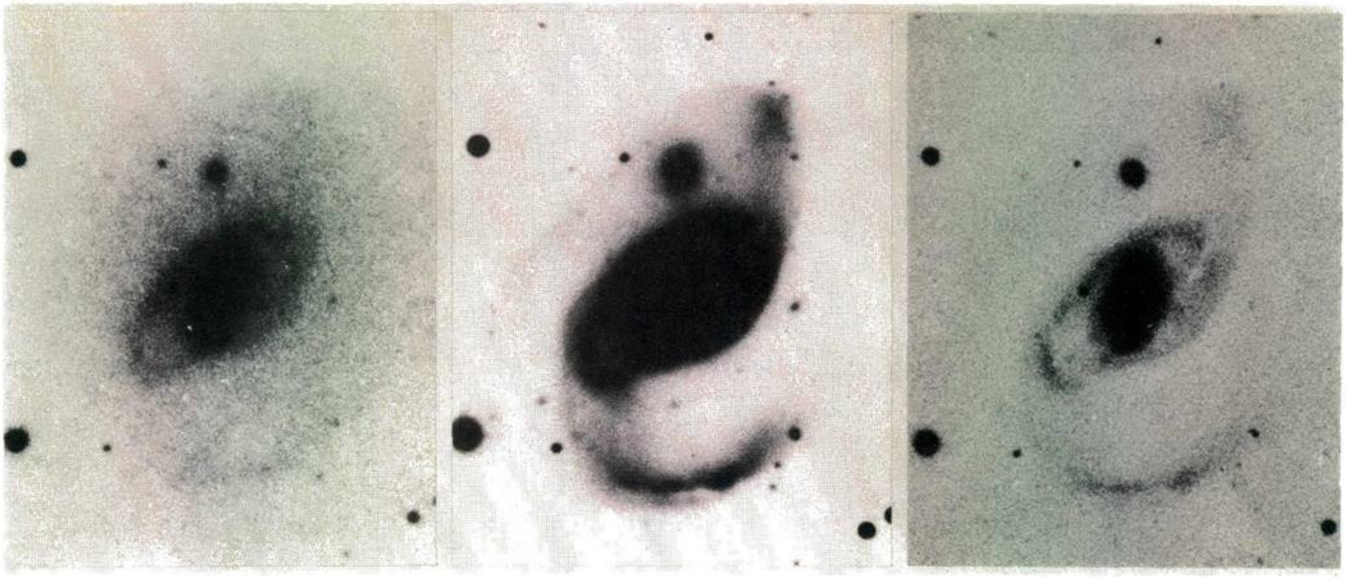
Even more amazing, a quasar's energy production rate has turned out to be far greater than first calculated. When astronomers measured quasars' infrared light output, they found them producing 10 times *more* energy in infrared than in visible and radio wavelengths combined!

How can a region so small (by astronomical standards) outshine entire galaxies several thousandfold? Even if these regions consist of supernovae (like the stars that explode every century or so in our own galaxy), we would need 1,000 explosions each year to generate the photon power released in quasars. Could there have been such an abundance of supernovae long ago? Or could some explosion far more powerful than supernovae explain the quasars' mighty roar? Among astronomers, one school holds that we accept quasars' enormous redshift as arising from the universe's expansion — even if we have no satisfactory way of explaining the tremendous energy output (making quasars the most distant and powerful energy sources ever discovered).

The other interpretation of quasars puts them closer to us, among the galaxies. This approach hinges on the observation that quasars appear positioned close to certain galaxies — merely tens of millions (instead of billions) of light-years away. If quasars really lie close to these galaxies and not just along our line of sight, they are 100 times closer than the distances we deduced from their redshifts. If these smaller distances are correct, then quasars are much less energetic than now thought. Astronomers might have overestimated quasars' brightnesses a full 10,000 times by assigning their distances incorrectly.

If quasars are 100 times closer than thought, then they are "merely" as bright as galaxies. Presumably, we would not have much trouble explaining their energy output — but would uncover what is causing the huge redshifts.

In the early days of quasar astronomy, some people suggested that gravitational forces produced redshifts. Any photon leaving a gravitational field — such as that on the surface of a star — will lose some energy. Photons leaving the sun lose about one-millionth their original energy; some white dwarf stars can raise this fraction to one-thousandth the photon's energy. But to increase the fraction of energy lost to 10, 50 and 90 percent levels measured in quasars requires fantastically strong gravitational fields. Such tremendous gravitational forces occur



Three photographs of the spiral galaxy NGC-4319 were taken with different exposures by Halton Arp at the 200 inch Mount Palomar telescope. This galaxy has a redshift indicating a recession velocity of 1,100 miles per second. Just below the galaxy is the quasar Markarian 205, which has a redshift corresponding to a recession velocity of 13,000 miles per second. Are these two objects close to each other in space, or do they just happen to lie along our line of sight? If the redshift interpretation is correct, quasar 205 is really one billion light-years beyond NGC-4319. Hale Observatories Photograph.

only near the boundaries of black holes, which capture even light. If quasars surround black holes, we would not expect to see any absorption patterns since atoms would be broken apart near the hole.

The leading advocate of nearby quasars is Caltech astronomer Halton Arp. Arp first suggested quasars appear close to certain types of spiral galaxies far too often for it to be chance. Princeton astronomer John Bahcall argues Arp's statistics are unconvincing. Bahcall recently demonstrated that Arp's photograph of a quasar, seemingly on the end of a galaxy's spiral arm, can easily be matched with a photograph of a star in our own Milky Way appearing to lie on the end of another galaxy's spiral arm. (The Arp-Bahcall debate is detailed in **The Redshift Controversy**, edited by G. B. Field.)

It has been suggested that quasars are shot from galaxies like popcorn. But two objections appear. First, why are all quasars moving *away* from us if galaxies shoot them out in all directions? Secondly, how could a quasar be accelerated to half the speed of light or greater without disintegrating? This seems as unlikely as launching a rocket with a hydrogen bomb.

Proponents of galaxy-launched quasars suggest taking a look at the galaxy NGC-7603 (see page 24). This galaxy has a redshift indicating a velocity of 5,500 miles per second away from us. Its companion galaxy (*not* a quasar), appearing connected to the larger galaxy by a filament of stars and gas, has a velocity of 10,000 miles per second away from us. Thus, these two supposedly connected objects differ by 5,000 miles per second in their velocities of recession. One or the other of the pair must have acquired a velocity kick of 5,000 miles per second in addition to the velocity given by the universe's expansion. If a relatively ordinary galaxy can acquire an extra boost of 5,000 miles per second, can we rule out the possibility that quasars somehow receive an extra boost by 60,000 or even 150,000 miles per second?

We can vaguely imagine processes accelerating a galaxy to a speed of 5,000 miles per second, but 150,000 asks too much. In our rocket analogy, we might be able to use explosions to accelerate a rocket to five miles per second. But if we tried for 150 miles per second, we would surely fail.

Although Arp's statistical arguments have convinced many astronomers, the majority remain either skeptical or downright hostile. Sir Fred Hoyle, the great maverick thinker among British astronomers, decided in 1972 that Arp's observations could not be dismissed. Hoyle recently told the American Astronomical Society that Arp's results indicated a crisis in our understanding of astrophysics because if quasars do lie close to nearby galaxies, their redshifts must arise from something that we simply do not understand. As Hoyle put it, "The implication is that cosmology will have a great deal to say about fundamental physics. This is a conclusion which many physicists and indeed many astronomers are trying hard to resist.... For each of us there is a decision to be made. Do we cross a bridge into wholly unfamiliar territory or do we try to remain safely within well-known concepts? This depends on how each of us sees the data."

Astronomers still see the data differently, and quasars remain an enigma either as a bridge to new territory or a reminder of our inability to explain the universe.

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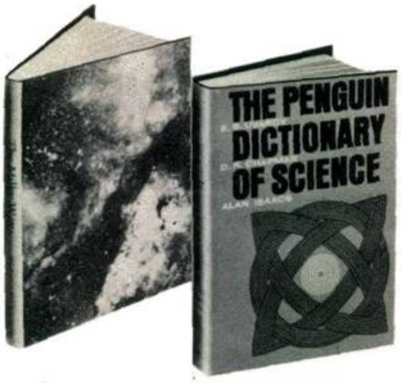

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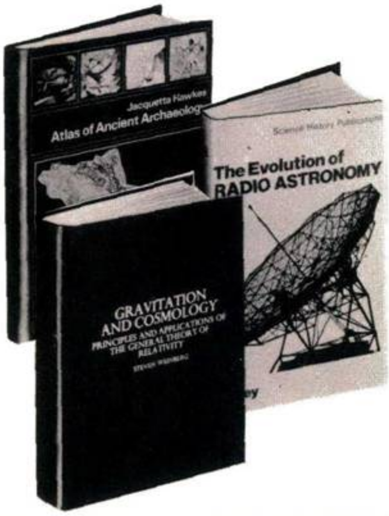
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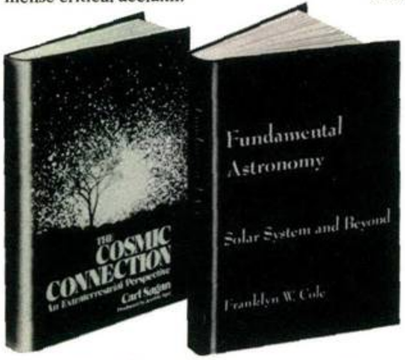

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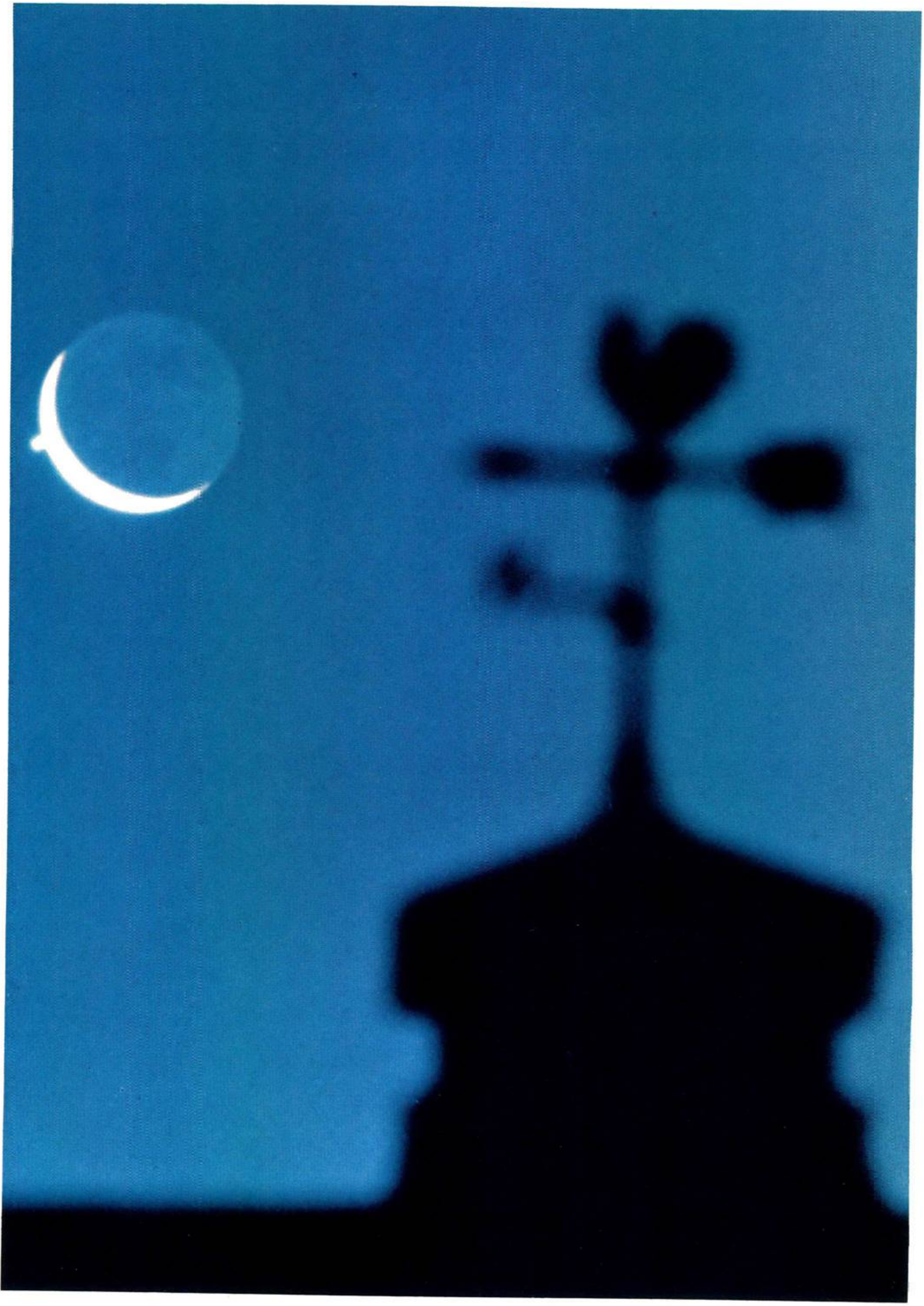
Vesta Makes Closest Approach to Earth

During September, all five visible planets are strung between evening and dawn. Mercury leads the procession as a sunset object; Jupiter, Mars and Saturn dominate the early morning sky, and exceptionally brilliant Venus precedes sunrise. The asteroid Vesta makes a fascinating addition, joining the early morning planets as it makes its closest approach to Earth for 1975. Under ideal conditions, Vesta may be visible as a naked eye object.

Mercury

The first planet of the September evening sky, Mercury appears above the western horizon for about 20 minutes following sunset. The moonlike world remains a zero magnitude object for most of September. Toward the end of the month Mercury becomes increasingly difficult to observe as it moves eastward in its orbit and closer to our line of sight

A weather vane "points" at Venus shortly before it disappears behind the moon in this July 17, 1974 occultation photograph. A 200mm f/3.5 lens recorded the impressive composition in a five second exposure on Kodachrome 64, a relatively new fine grain transparency film. The next chance for photographing a Venus occultation will not come until May 14, 1977. Photograph by David Healy.



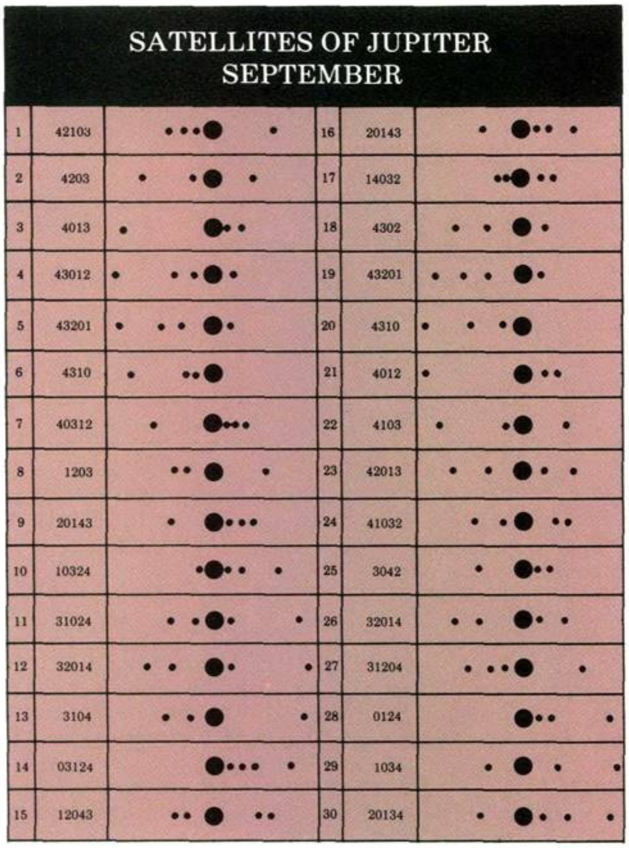
with the setting sun. On the 26th, Mercury changes direction — beginning a westward or *retrograde* motion. The tiny planet's disk increases from 5.8 to 9.3 seconds of arc by the 30th, displaying quarter phase at midmonth.

Venus

Rising about one hour before the sun, Venus is a prominent object in the morning sky. Beginning the month at -3.6 magnitude, Venus reaches a splendid -4.3 magnitude by the 30th. During September, Venus' disk grows from a thin sliver of light (three percent phase) to a 25 percent phase. Orbiting the sun at 78,000 m.p.h.—12,000 m.p.h. faster then Earth—Venus is now speeding ahead of us, increasing its distance from 26.7 million miles on the 1st to 38.5 million miles by month's end.

Mars

Mars is following and now appreciably outshining Aldebaran, the red eye of Taurus, at 0.0 magnitude. The planet rises at approximately 11 p.m. early in September—about 2½ hours after mammoth Jupiter. Later in the month, Mars rises at about 9:30 p.m. The gap between Earth and Mars narrows to 80 million miles, bringing the red planet 17 million miles closer to Earth by month's end. As Earth gets closer to the planet, its angular diameter increases from 9 to 10 seconds of arc. Mars will be positioned for better observing later this year as it approaches opposition.



SATELLITES OF JUPITER
SEPTEMBER

1	42103	16	20143
2	4203	17	14032
3	4013	18	4302
4	43012	19	43201
5	43201	20	4310
6	4310	21	4012
7	40312	22	4103
8	1203	23	42013
9	20143	24	41032
10	10324	25	3042
11	31024	26	32014
12	32014	27	31204
13	3104	28	0124
14	03124	29	1034
15	12043	30	20134

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 2 a.m. (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0= Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

Satellite Shadows on Jupiter

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Sept. 2	1	12:54 a.m.	3:04 a.m.
	3	8:55 p.m.	11:35 p.m.
4	2	2:14 a.m.	4:56 a.m.
9	1	2:48 a.m.	4:59 a.m.
10	3	12:58 a.m.	3:35 a.m.
	1	9:16 p.m.	11:27 p.m.
11	2	4:51 a.m.	7:32 a.m.
16	1	4:42 a.m.	6:53 a.m.
17-18	3	4:59 a.m.	7:35 a.m.
	1	11:10 p.m.	1:21 a.m.
21	2	8:46 p.m.	11:27 p.m.
25	1	1:04 a.m.	3:16 a.m.
26	1	7:33 p.m.	9:44 p.m.
28-29	2	11:23 p.m.	2:04 a.m.

1=Io
2=Europa
3=Ganymede
4=Callisto

Jupiter

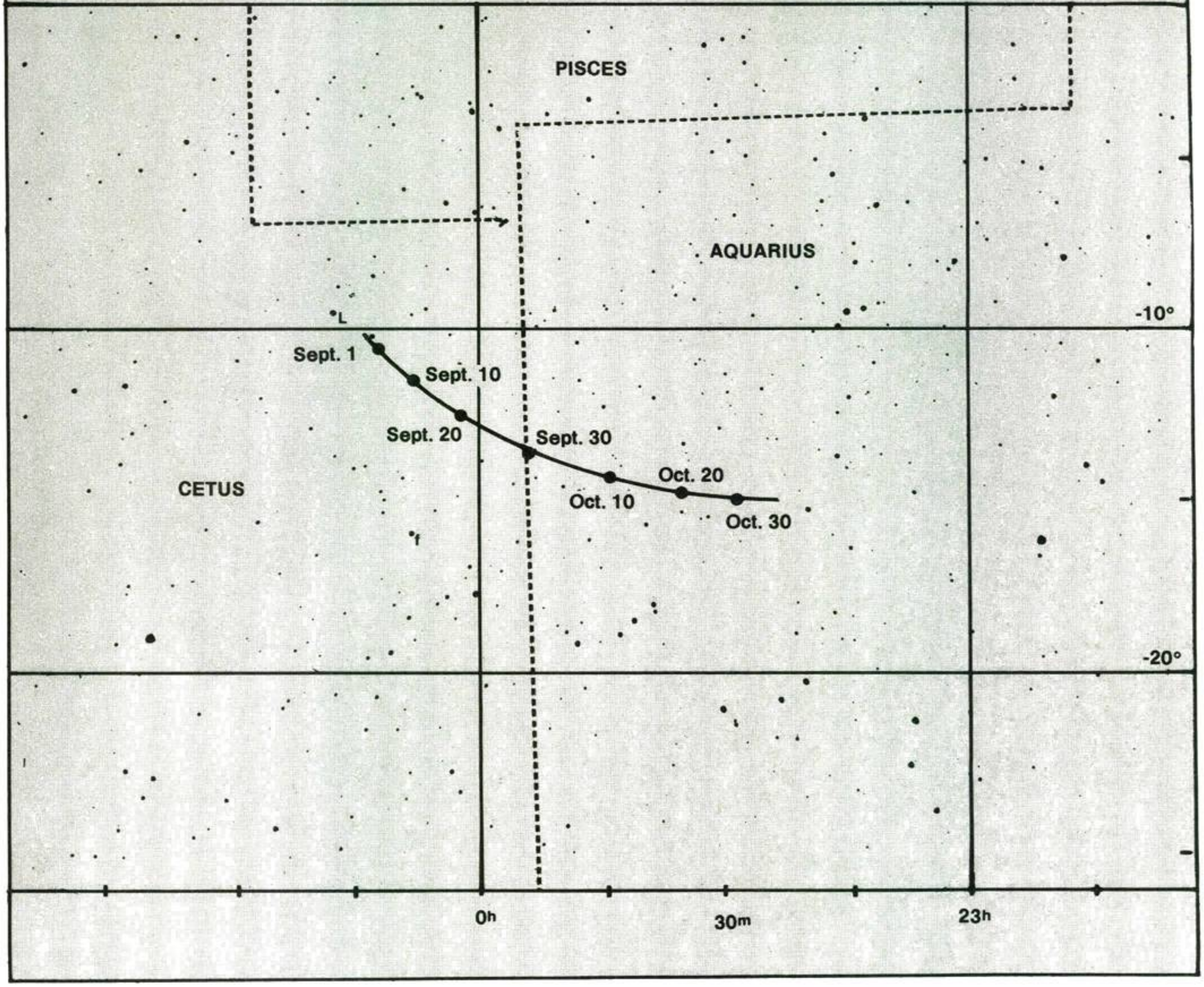
Rising soon after sunset (about 8:30 p.m. and 6:30 p.m. later in September), the largest member of the solar system remains in the sky almost all night during most of the month, allowing favorable observing. By the end of September, Earth is within 370 million miles of the planet. As our distance from Jupiter decreases, the angular polar and equatorial diameters increase from 44 to 46 and from 47 to 49 seconds of arc respectively. Its magnitude changing from +0.2 to -0.1, Jupiter lords attention over the dim constellation Pisces throughout the month as Earth and the giant draw nearer to one another.

Saturn

Saturn (father of the great god Jupiter in

Cratering detail in the lunar highlands is prominent in this view of the six-day-old moon. The telescope used was a six inch home built, f/10 refractor equipped with a 28mm Kellner eyepiece. A Yashica-D twin lens reflex camera using Verichrome Pan film (ASA 125) captured the moon in a 1/15 second exposure. The film was developed in Microdol-X at a 1:1 ratio for 10 minutes. Photograph by Danny Sagstetter.

PATH OF VESTA SEPTEMBER~OCTOBER 1975



mythology) does not rise until late in the night—about 2 a.m. By the end of September, it rises near midnight—but observing will not be very favorable, as the planet is not well up in the eastern sky until almost dawn.

We are approaching Saturn, and our distance from it decreases by 16 million miles during September—a change from 911 million to 875 million miles. Saturn, now in the constellation Cancer, increases in angular diameter by approximately 1/2 second of arc (from 17 at the rings and 15.5 seconds of arc at the poles).

Vesta

The asteroid Vesta passes within 129 million miles of Earth on Sept. 18—the closest approach it will make during 1975. At opposition Vesta reaches +6.3 magnitude, though in previous oppositions the asteroid has grown as bright as +5.5.

Early September promises the best chance for glimpsing Vesta since the moon does not yet interfere with early morning observations. Because Vesta will be bordering on the naked eye limit for sky observation (+6.0 magnitude), binoculars are recommended. The map on page 32 shows Vesta's path through the constellations Cetus and Aquarius. Observers may want to attempt tracking Vesta's relatively swift night-by-night motion against the star background. In fact, its motion is detectable even during one night's observation. For astrophotographers, guided time exposures taken several days apart make an interesting record of Vesta's brief flyby. ASTRONOMY will welcome amateur photo submissions of Vesta.

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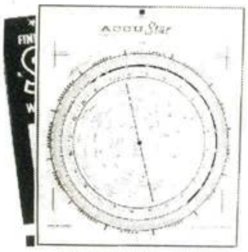

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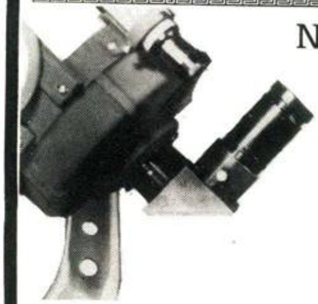

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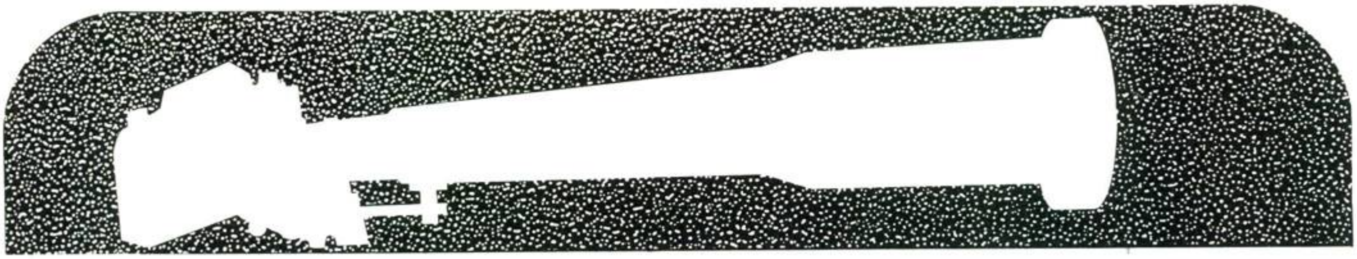


PHOTOGRAPHY IN ASTRONOMY

STAR GALLERY '75

Photo submissions from our readers have again prompted a gallery of sky portraits gathered over the months. A wide variety of subjects and photo techniques are illustrated here, as continuing interest in the sky encourages photographers to record the "heavenly host" of objects available every clear night.

A) Our jaunt through the sky beings with Earth's closest neighbor, the moon. Photo A records the full face of our only natural satellite as seen on July 3, 1974 from Birmingham, Ala. Conrad Kussner took the photos on Kodachrome 25, and submitted this exposure taken at the prime focus of his Celestron 8 telescope. Kussner used a Bessler-Topcon Super D 35mm camera and a 1/30 second exposure to obtain

A Photograph by Conrad Kussner

B Gates Planetarium Photograph

C Photograph by Kevin Parker

fine resolution and excellent contrast. He found that locking the mirror of his camera in the "up" position and using the camera's timer produced even sharper pictures than when a cable release was used.

B) Over 1,200 people enjoyed the eclipse in Denver, Colo. when the Gates Planetarium set up several telescopes to observe and photograph the event. This photo submitted by the planetarium staff was taken through a 3.5 inch f/16 Questar just as the moon emerged from Earth's shadow. A 25 second exposure on High Speed Ektachrome pushed to ASA 400 and then duplicated brought up the contrast in the photo, but also increased the grain. A Pentax Spotmatic II was used and the exposure was guided at lunar rate rather than the usual sidereal rate.

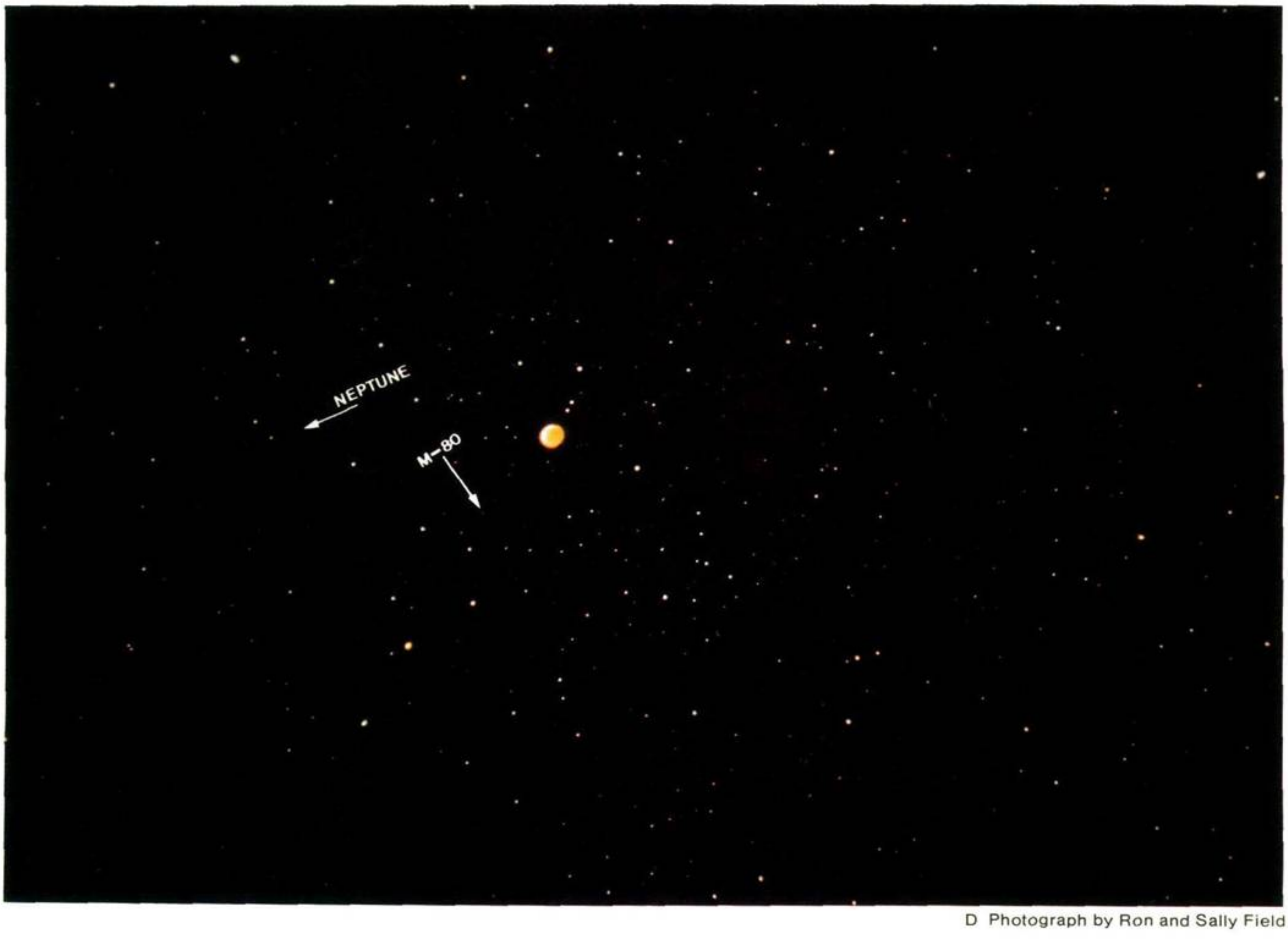
C) A 2-1/2 hour time exposure recorded the progression of the eclipse in Berkeley, Calif., revealing ground detail and the extreme variations in the moon's brightness during the eclipse. A tripod-mounted Canon single lens reflex camera was used with High Speed Ektachrome at regular ASA 160. A 50mm lens at f/16 prevented overexposure during the long time interval.

D) Another California photograph — this time from Monterey County — recorded not only the eclipsed moon, but M-80 and the elusive planet Neptune as well. A Miranda D camera (mounted piggyback on a Celestron 8) utilizing a 50mm lens at f/2 exposed High Speed Ektachrome (ASA 160) for 10 minutes. The photographers processed the film in Kodak E-4 developer.

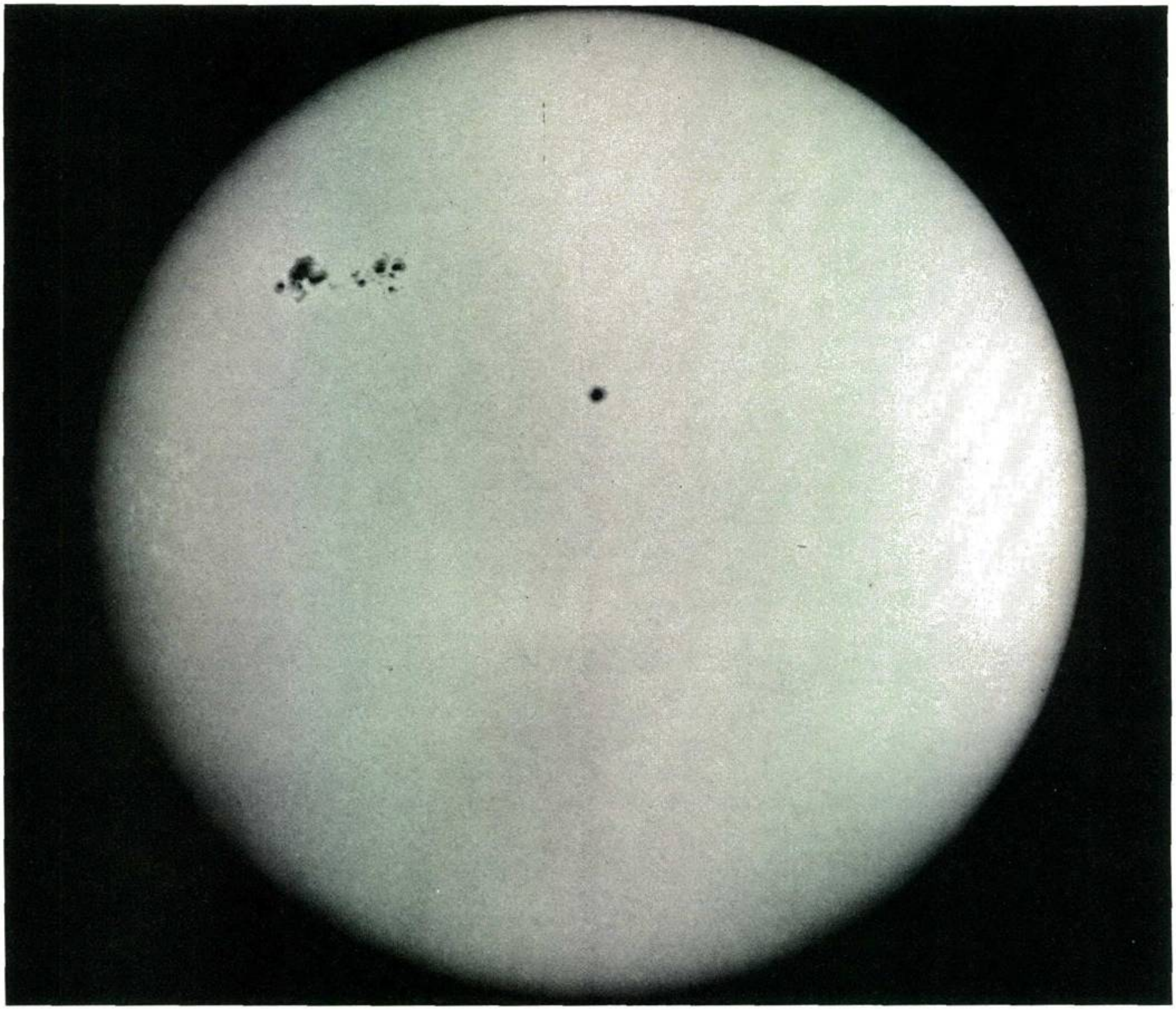
E) Moving farther away from Earth, the nearest star was recorded with an eight inch Celestron (f/10) and solar filter. High contrast copy film exposed at 1/125 second in a Nikon F camera mounted at prime focus yielded the end result.

F) Reaching out in the solar system, this black and white photo of Saturn captures much detail. Kodak SO-410 film was exposed for seven seconds, developed in D-19 for four minutes at 73 degrees Fahrenheit, and then printed on #3 contrast paper. The photo was taken from Naples, Fla. through an eight inch home built Newtonian telescope utilizing 7mm eyepiece projection. Obviously, photographing the planets requires much patience and care.

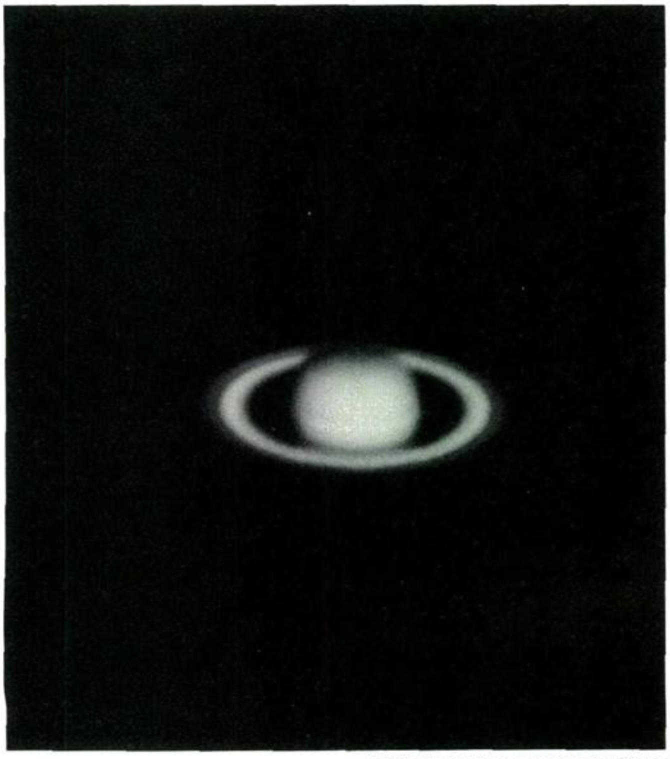
G) An hour exposure using off-axis guidance and an 8 inch Celestron Schmidt-Cassegrain f/10 telescope yielded this photo of M-33 in Triangulum. Taken north of Golden, Colo. on 103aF film in a Nikon back, the photo also recorded a tumbling artificial satellite as it intruded on one of the galaxy's spiral arms (the regular dimming and brightening of the satellite streak indicated the tumbling). The film was developed in D-19.



D Photograph by Ron and Sally Field

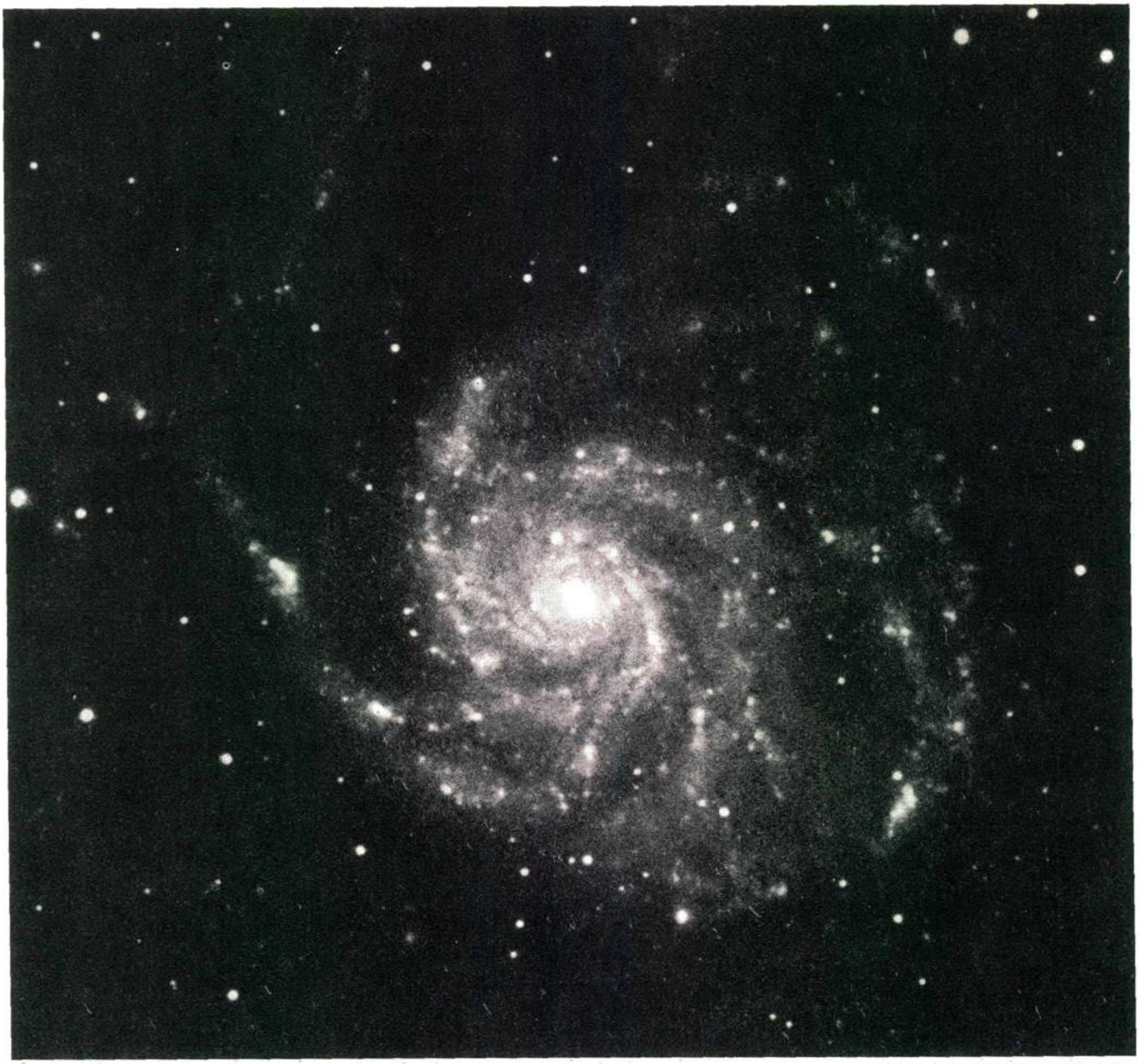


E Photograph by John Sanford



F Photograph by James K. Rouse

G Photograph by Robert Beshore



H Photograph by Evered Kreimer

H) Beyond our galaxy lie the deep sky objects – galaxies and star clusters that await a photographer's attention and patience. Here, a low-temperature camera coupled with a 12-1/2 inch f/7 telescope captured M-101 in the constellation Ursa Major. The 10 minute exposure on Tri-X and the increased film sensitivity due to the cold camera produced the excellent detail in this photo.

Many photographic techniques are illustrated in this photo tour through the skies. Some of them are relatively simple methods that anyone equipped with a good single lens reflex camera and steady tripod can attempt. Others – such as those recording galaxies and other deep sky objects – require more sophisticated equipment, and greater experience and experimentation with films, exposures and printing techniques.

Be sure to follow Photography in Astronomy each month for tips on making your own sky portraits. In no time at all, yours could be showcased in an issue of ASTRONOMY. If you have a special technique for sky shooting, drop us a line – we'd love to hear about it, and other ASTRONOMY readers could benefit by your experience.

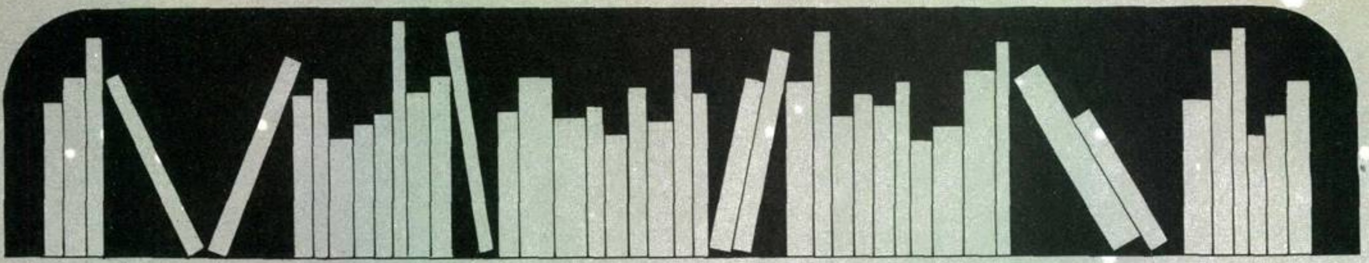
How to Submit Photographs

1. Be sure your name and address are on each slide or print.

2. If you submit black and white prints, be sure they are well focused and free of fingerprints and dust spots.

3. Do not submit photos printed on a silk textured surface. Prints should be glossy or flat surfaced only.

4. Be sure to include the type of telescope and/or camera used, the manufacturer and brand or model name, as well as all pertinent data concerning the scope/camera hookup. If your telescope is home built, let us know that too. ◆



NASA Activities

24-32 pages per issue*
published monthly by NASA

This in-house magazine is published for the information of NASA's employees, and contains items on personnel transfers, promotions and awards, savings bond and blood donor drives, and a "low-cost corner" on how to save the taxpayers' money.

However, the rest of the magazine is quite informative. Mission descriptions and project summaries are well written, with special sections for monthly highlights and future launch schedules. News releases and Congressional testimony by high NASA officials are full of interesting information. A special monthly section called "Your 1¢ Worth From Space" details new spinoffs and Earthly benefits from outer space technology.

Generally, this good source of current data on American space activities and NASA is written for the average NASA employee — not project scientists.

* *Single copies, $.60; annual subscription, $6.70. For sale by U.S. Government Printing Office.*

◆

Workshops in Space

by BEN BOVA

67 pages, hardcover, $6.95
E. P. Dutton and Co., Inc. (1974)

Although some observers claim that newspapers and NASA handouts are written for people with a fourth grade education, youngsters looking for information on space exploration usually must be satisfied with adult materials. This little book for grade schoolers provides a well written and detailed account of contemporary manned space projects.

The book describes what the author calls "phase II" of manned space exploration. After the initial phase of exploratory voyages, space flight is now concentrating on means of exploitation of space resources for human benefit.

Bova begins by outlining the history of the 1973-74 Skylab flight, as well as the importance of Earth resources experiments conducted on manned and unmanned satellites. He then talks about international space efforts which led up to the Apollo/Soyuz Test Project. Here the author unfortunately depended on a very preliminary flight plan, so his description of the mission is seriously in error. The final chapters of his book describe the Space Shuttle (but not the Spacelab module) and other new frontiers in space.

The book is an adequate overall summary of space flight in the 1970s, written with a precise audience in mind. It is a good children's book which does not oversimplify technological questions. Best of all, it is not the kind of space book that will become obsolete or outdated quickly.

◆

The New Frontier

by ERIC BURGESS

8 pages, paperback, free*

This short but well-stocked periodical was designed for teaching about the interplanetary explorations of Pioneer, Mariner, and Viking spacecraft. Flight plans and scientific discoveries are outlined and explained in each issue, along with an outstanding set of photographs and drawings. Study projects which help to understand actual space missions are described at the end.

Most of the current series of pamphlets (which appear several times a year) deal with Pioneer flights to Jupiter. Future issues will specifically address Viking flights to Mars. In many cases, the material presented is generally unavailable in the press since it is far more detailed than most readers want.

However, the details are clearly presented in a brisk, lucid style. Discoveries are discussed with their implications to other areas of science. An extended reading list is offered for more study.

This series is a must for science teachers in all schools. As an experimental publication, its long-range future depends on the demand.

* *Published periodically by NASA Ames Research Center. Free to educators; write Educational Programs Officer, NASA-Ames Research Center, Moffet Field, CA 94035.*

◆

Exploration of the Solar System

edited by ARTHUR HENDERSON JR. and JERRY GREY

67 pages, paperback, $2.05*
U.S. Government Printing Office (1974)

This NASA-sponsored reprint of the main articles in a special issue of **Astronautics and Aeronautics** is a timely, concise and well-organized overview of present efforts to explore the solar system. Technology, mission strategy and long-term planning are balanced to give the "big picture" of NASA's deep space program — a program beset with financial problems and ironically coinciding with its greatest successes. While Pioneer, Mariner and Viking probe new frontiers in 1975, this booklet describes the repercussions of current budget cuts on future missions.

The technology of interplanetary exploration is covered adequately, with sketches and descriptions of Pioneer 11, Viking, Mariner 10 and Helios spacecraft. An introductory chapter summarizes man's findings (as of press date) about the sun, planets, moons, asteroids and comets.

This book is exceptionally strong in its development of current mysteries and inconsistencies of man's knowledge, pinpointing areas worthy of further study. Why is the loss of helium from Earth's upper atmosphere so much greater than predicted? Why have Venus and Earth — similar in so many respects — evolved along such different lines? Where do comets come from?

After identifying present technological capabilities and areas for research, the authors outline a strategy for exploration. NASA's optimistic plans — which call for no breakthroughs in technology — have had to be delayed; in many cases special planetary alignments will not wait, and some special opportunities like the "Grand Tour" to all the outer planets on a single shot have been abandoned.

Finally, what is the purpose, cost and benefits of solar system exploration? What value does a budget planner put on knowledge? This fine little booklet presents some cogent answers to pressing questions in a period of economic recession.

** Stock number NAS-1.19:122; for sale by Superintendent of Documents, Washington, D.C. 20402.*

The Rush Toward the Stars

by TOM LOGSDON

222 pages (illus.), hardcover, $6.80
Franklin Publishing (1970)

Where has this delightful book been hiding? Published without fanfare soon after the first Apollo moon landings, this little volume has got to be the sleeper of the year. Billed as "a survey of space exploration", this text was born from a collection of lecture notes designed for nontechnical people interested in space technology. It is one of the best introductions to the many facets of astrodynamics and spaceflight engineering currently available.

The chapters consist of assorted short subjects on some of the most important disciplines of space flight: exobiology (life on other worlds), celestial mechanics (the paths of planets and space probes through space), launch vehicles and rocket propulsion, artificial satellites, and an introduction to space age math. Each topic is introduced, illustrated with interesting and sometimes far out examples, and placed in perspective with regard to space engineering.

For students wanting to know what a space engineer really does for a living, the case history of one space project is described graphically. The planning, problems and eventual success of this effort (space testing of the first Echo balloon satellites) forms a unique and invaluable chapter.

The style is witty, lucid, perhaps occasionally a bit flippant — it's sometimes hard to tell whether or not the author is joking. Although many subjects are introduced and explained, the pace remains fast. Some items are touched on superficially — often with abrupt transitions. Nevertheless, the style saves dry but crucial topics and sparks interest in what could have been boring.

Excellent analogies (the "gravity well" image in celestial mechanics) and examples (the actual flight path engineering for the Saturn 5) are well chosen. Did you know that the low density of the fuels of the S-2 stage resulted in a 3,000 pound buoyancy force at launch? On the other hand, more than 1,000 pounds of ice clings to the skin of the rocket at liftoff. These real complications have had to be dealt with.

The author's dedication is "to people everywhere who believe that if God hadn't wanted man to step off into outer space, He wouldn't have dangled the stars so temptingly." Especially for those interested in helping build or fly the space vehicles of the future, this book presents a beautiful and seductive introduction.

Conquest of Space in the USSR

edited by G. I. PETROV

444 pages (illus.), hardcover, $9.00*
Amerind Publishing Co., India (1973)

Sons of the Blue Planet

by L. LEBEDEV, et al.

327 pages, hardcover, $9.00**
Amerind Publishing Co., India (1973)

The publishing history of these two books is perhaps more interesting than the books themselves. When the American foreign aid loans to India were duly repaid (in Indian Rupees), the Indian government decreed the money could be spent only in India. In time, the United States government accumulated a stockpile of cash in a New Delhi bank. NASA countered with a plan: Use the money to hire English-speaking, Russian-educated Indian scholars to translate Russian scientific books and magazines into English for publication by the U.S. Government Printing Office.

The physical results of this idea are excellent. The books are more handsome in binding, printing and illustrations than were the original Moscow editions. The translations are outstanding, correctly conveying often difficult Russian technical phrases into clear, precise English.

Less pleasing is the hefty price tag. Since most of the costs have already been paid in otherwise nonproductive American-owned rupees, it appears that the profit is not justified. The books, bluntly speaking, are not worth half the list price.

The books are direct translations of two propagandistic Soviet volumes written in glowing praise of the Soviet space program. To a knowledgeable reader, the typical Soviet propaganda techniques are plainly evident: Omission or distortion of facts that do not fit, moralizing the characterization of Soviet space heroes, denigration of American space accomplishments by implication or outright assertion.

Petrov's book is a collection of official TASS News Agency releases about Soviet space shots between 1967 and 1971. The sequence begins just after the death of the Soyuz-1 pilot and ends shortly before the deaths of the Soyuz-11 crewmen — both events which the USSR would rather ignore. The first successful moon robot missions (after a half dozen failures which are not discussed) are described in considerable detail, as well as the respectable successes of the Soviet Venusian atmospheric probes.

The second book purports to describe the Soviet space pilots. Exciting scenes from their early lives, training and space flights are transformed into bland and repetitive political propagandizing. Each cosmonaut is portrayed as a perfect hero model for young Communists.

There is abundant interesting raw data found in these books — facts and reports which have not been generally available to the West without direct Russian contacts. But NASA should have written a preface or a disclaimer, describing the sources of these books and issuing a warning about the credence of the content. Unfortunately, in the era of space detente, NASA has not found it desirable to notice Soviet space distortions — and as a result has done American readers of these books a gross disservice.

** Stock number NAS-1.13/2:F-725.*
*** Stock number NAS-1.13/2:F-728.*
Both are available from the National Technical Information Service, Springfield, VA 22151. Orders must be prepaid.

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GAZER'S GAZETTE

Let's Take a Look at the Sun... Cautiously

by
Lauray D. Yule

From earliest times, the sun has been an object of veneration for both primitive and civilized men — worshiped openly in many societies such as ancient Egypt and Greece.

Despite being an object of past worship and the closest star to us, the sun receives relatively little attention from observers. This may be because of the dangers involved in observing the sun — dangers that are real but easily minimized with proper precautions. Or it may be our star seems to have so little to offer — but this simply isn't true. The sun is constantly active, revealing some of its surface changes through granulation, sunspots and faculae — all easily observed solar features — when studied under proper and safe conditions.

The sun is the most massive body in our solar system — 333,420 times more massive than Earth (if Earth weighed 1/10 ounce, the sun would weigh three tons). Its average density, however, is low compared to Earth's — about 1/4 as much.

A diameter of 864,000 miles makes our star just over 100 times the diameter of Earth — but because it is 93 million miles away from us (92,957,000 miles to be exact), the sun subtends an angle of *just over 1/2 degree* in the sky. Actually, because Earth's orbit is slightly elliptical, we approach about three million miles nearer the sun in our northern hemisphere winter than in our summer, and the apparent size of the sun varies slightly.

The sun's gravity is 28 times that on Earth (one pound here weighs 28 pounds on the sun). It rotates once on its axis in about 25 days — but since Earth's orbit is in the same direction, it appears to rotate once in about 27 days as seen from Earth. "About" is used, because the equator on the sun goes around appreciably faster than the higher latitudes.

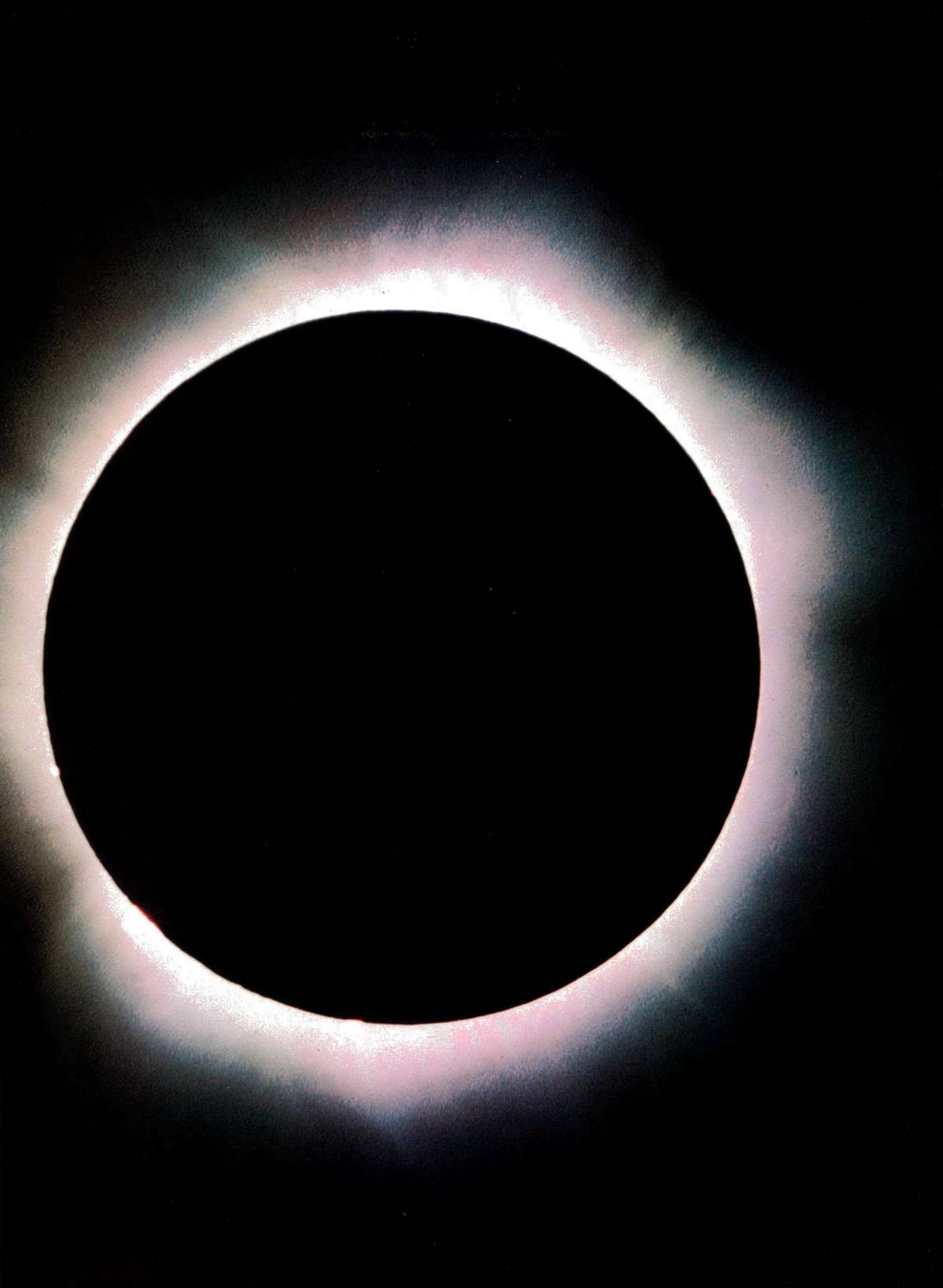
The sun's axis is tilted at an angle of a little more than seven degrees to the ecliptic. During the year the angle changes, varying seven degrees from maximum to minimum in each direction. Therefore, when observing the sun, you will seldom see it straight on (perpendicular to its east-west motion).

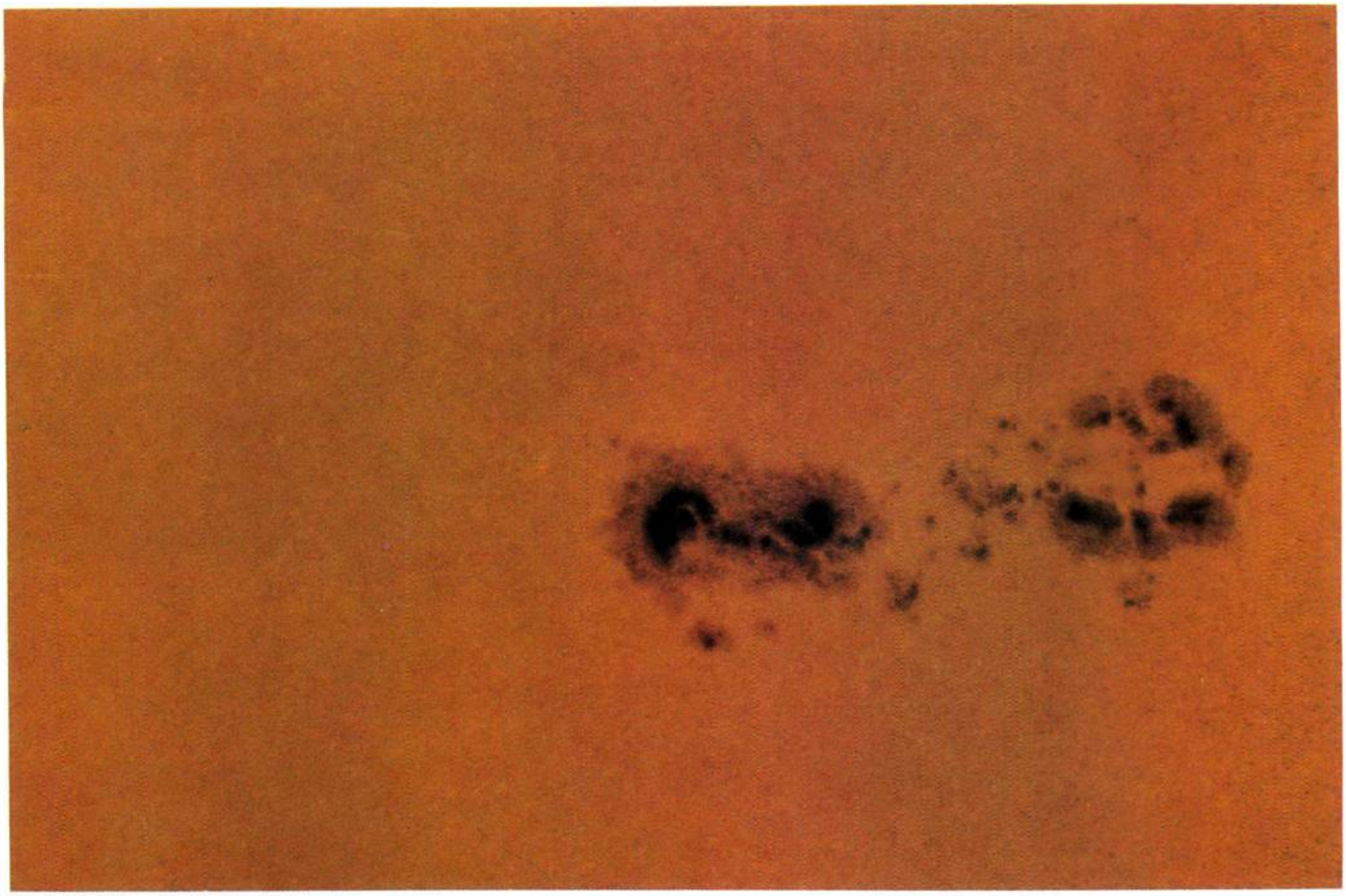
Solar Observations

Most telescope users are aware of the potential dangers involved when observing the sun. But if you are a beginner, there are several things you must know before starting to observe.

Have you ever tried looking at the noonday sun

The drama and beauty of a total solar eclipse, revealing the restless corona, was recorded March 7, 1970. High Speed Ektachrome exposed for 1/60 second in a Mamiya Sekor 500 DTL at the prime focus of an eight inch Cave reflector captured totality, utilizing proper filtration methods. Photograph by John Guth.





The dynamics of a sunspot, photographed with eyepiece projection through a Celestron solar filter, reveals the colorful detail viewed when using these perfectly safe and convenient filters. They protect the observer's eye and keep the telescope optics safe from the sun's heat and radiation. Celestron Pacific Photograph.

on a clear day with unaided eyes? Nature tells you at once this isn't advisable: The body's protective reactions force you to look away. Have you ever taken a magnifying glass, caught the sun's rays, concentrated them on a leaf or other object and observed the smoldering hole it creates? Imagine what would happen to your eyes by looking at the sun through the unfiltered optics of binoculars or a telescope that captures and concentrates light on one spot. And the damage can be done in a fraction of a second! The intensity of heat and light coming into your telescope must be reduced by something between 99.9 and 99.999 percent before it can be safely viewed.

Projection

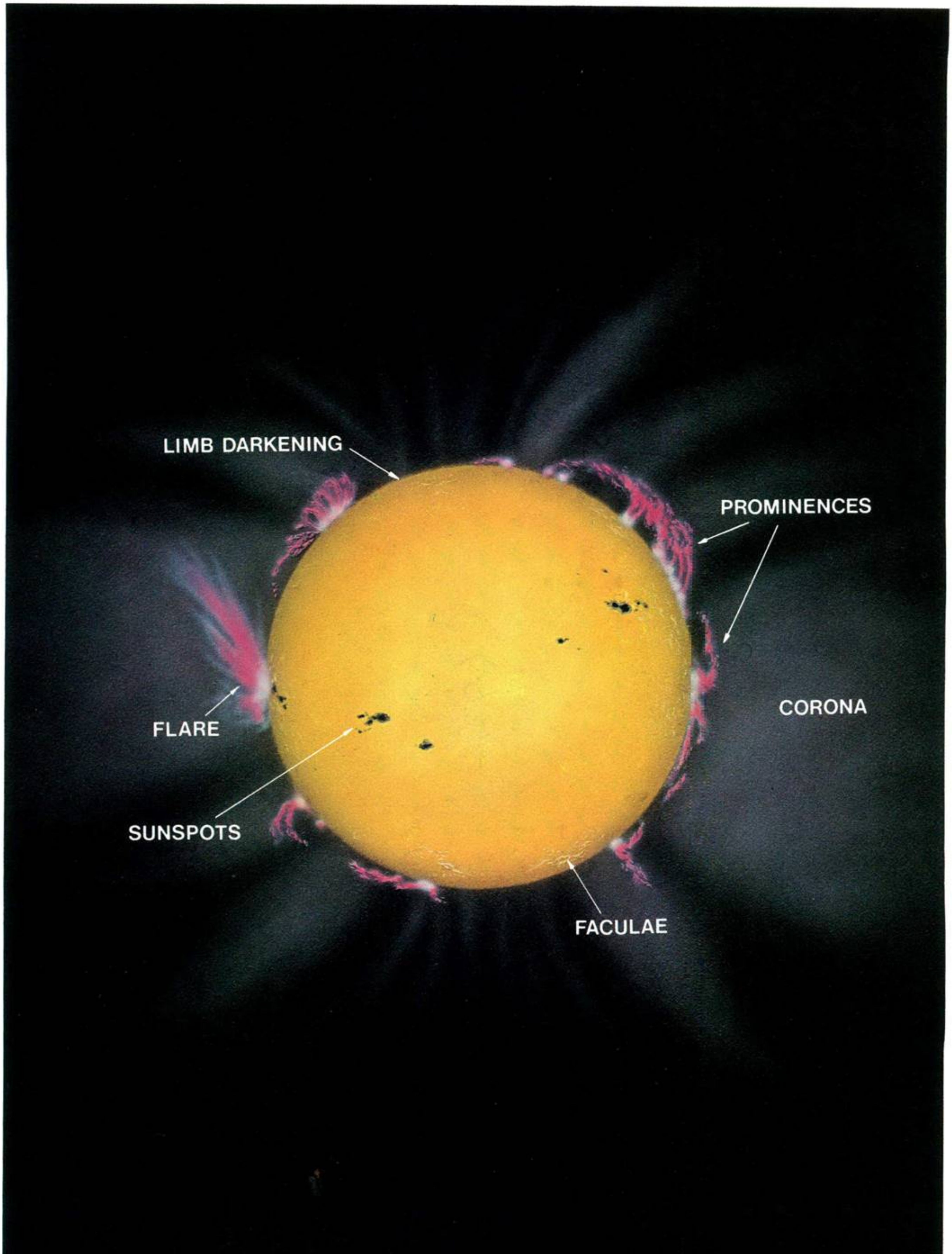
The simplest way to observe the sun is by projecting the image through an eyepiece and onto a screen. This method is safe, and the image produced is generally large enough to be viewed by several observers. But *don't use an expensive orthoscopic eyepice* (or *any* cemented eyepiece). So much heat is generated by the sun's concentrated rays that the balsam melts, ruining the eyepiece. Instead, use an inexpensive Huyghenian (old microscope eyepieces are like this) or Ramsden of 1/2 to 1 inch focal length. Use moderate magnifications — the highest that will give you a complete disk of the sun on your screen. Solar objects are best observed in relation to each other when the whole surface is visible. The image should be projected onto a flat white surface such as tag board or plaster.

Ordinarily, a telescope of moderate aperture — at least four inches or more — is needed to resolve fine detail. The main solar features (spots, faculae and granulation) are well seen with a 2.4 inch, but not in detail.

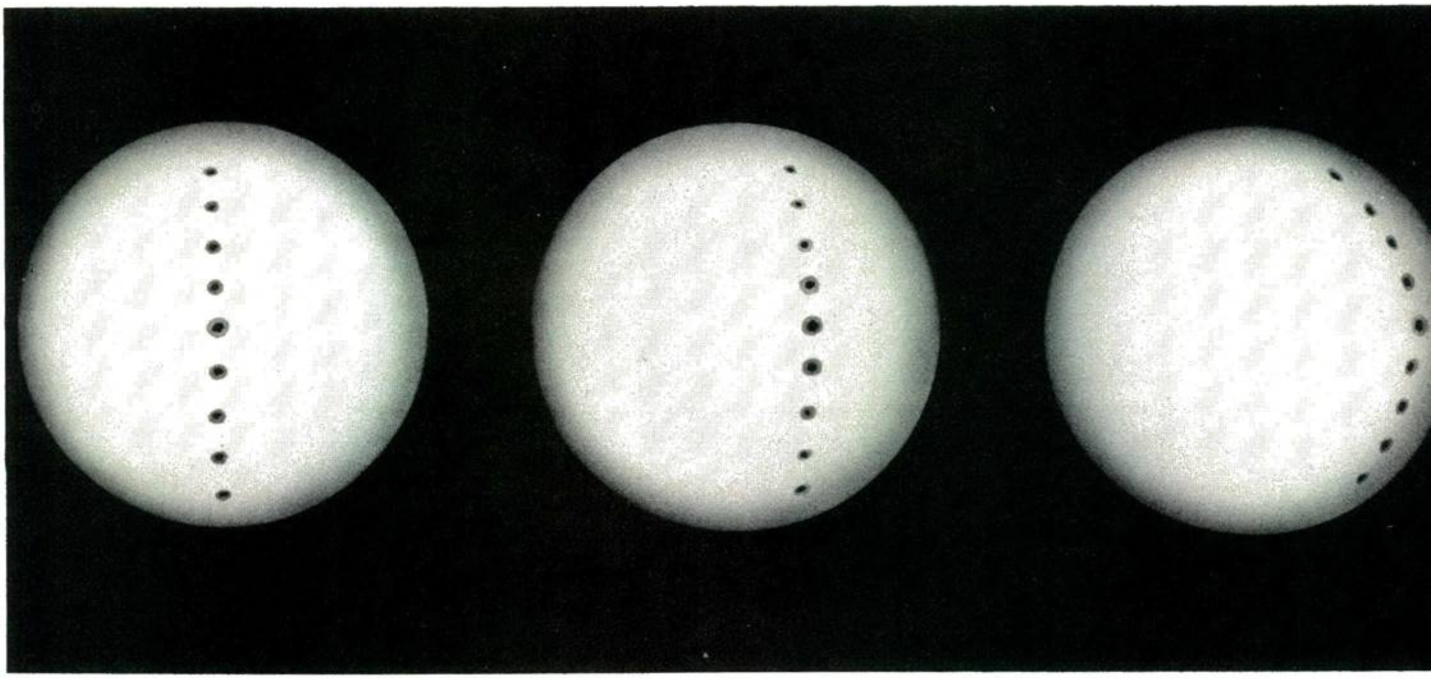
Many small telescopes come complete with a solar projection screen, but if yours doesn't, one can be built both easily and inexpensively.

With your projection screen in place, find the sun by adjusting the tube until it makes the smallest possible shadow on the ground. The sun must now be nearly centered, and the telescope probably needs only slight adjustment to bring the image onto the screen. Sighting along the telescope is dangerous since the eye is directed at the sun's full glare. *Another word of warning: If your telescope has a finder, remove it completely or put a cap over it.* It is far too easy to forget that looking at the sun through a finder is as dangerous as looking through the main telescope.

The distance of the screen to the eyepiece is best left to trial and error since it depends on image diameter desired and eyepiece focal length. Typically,


LIMB DARKENING
PROMINENCES
FLARE
CORONA
SUNSPOTS
FACULAE

This stylized representation of the sun reveals constant dynamic activity, all of which can be viewed through small telescopes properly filtered and equipped with various accessories. Artwork by Victor Costanzo.



leave one to two feet from eyepiece to screen, then adjust focus. Focusing the image at the beginning of an observing session will be difficult because the sun's heat changes the curves in the optical system.

Direct Observation

The best method for observing the sun through telescope optics involves using a full aperture solar filter which fits over the front of the telescope and reflects light and heat before it ever enters. The filter permits safe, direct viewing of the sun — allowing only about 1/100,000 of the normal brightness to pass through. The filter keeps the optics cool, and removes the danger of their cracking. Solar Skreen (available from Roger W. Tuthill Assoc., Inc., Box 1086AA, Mountainside, N.J. 07092) and Celestron Pacific's (2835 Columbia St., Torrance, CA 90503) filters are excellent, and range in price from $25 to $250.

Two other methods of direct observation involve using a solar prism or a Herschel wedge. A right-angle prism with perfectly flat, polished surfaces is an almost perfect light transmitter. But if it is turned correctly, it acts as a reflector. Since many Newtonian reflector telescopes use such prisms to bend the light train toward the eyepiece, it is a relatively simple matter to adjust the prism mounting for solar observation. The adjustment reduces light reaching the eyepiece by 95 percent (still well above the safe limit), and a neutral density filter of 1 to 1.3 must be used in front of the eyepiece. Better still, a Herschel wedge may be inserted in the eyepiece drawtube on a refractor. The wedge is mounted in its own fitting, of which one end fits the drawtube and the other accomodates the eyepiece. The Herschel wedge does not require any changes in optical parts, and it can be quickly inserted and removed — two important advantages. But it is not convenient for Newtonian reflectors, and like the solar prism it should be supplemented with a neutral density filter.

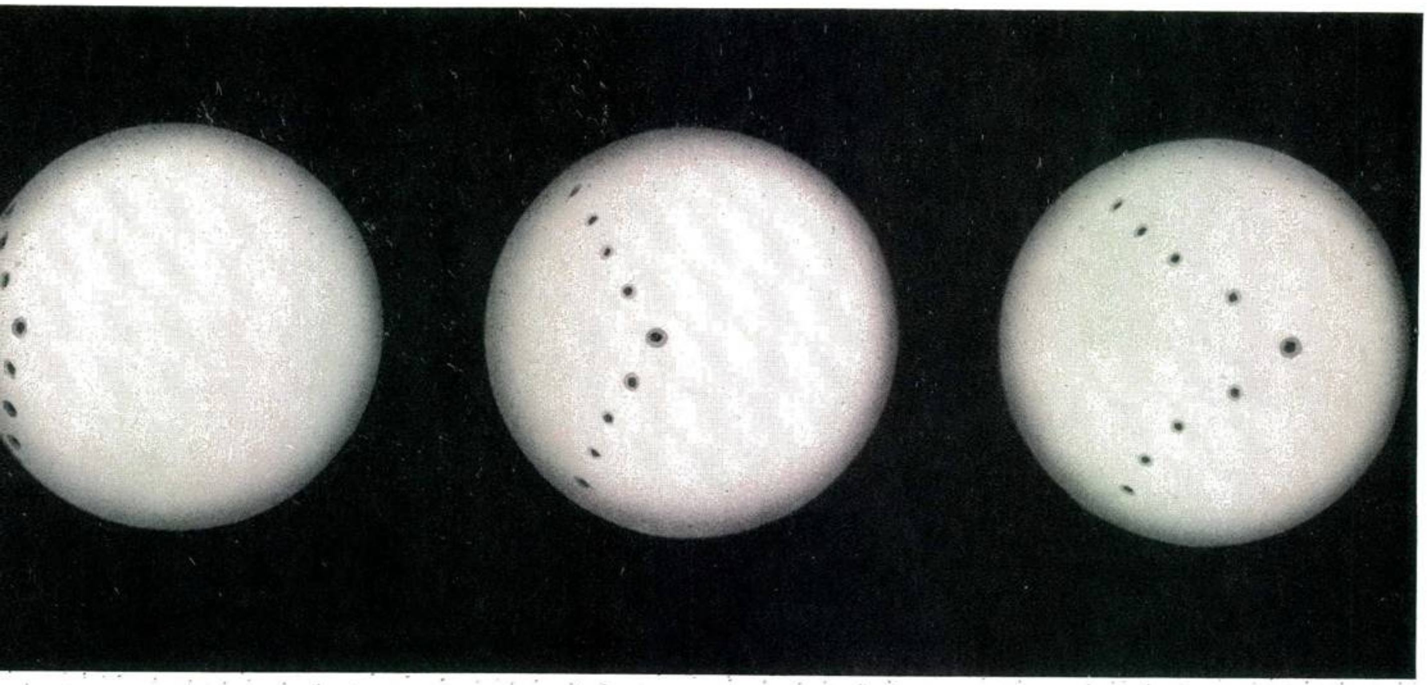
The sun's light intensity can be reduced in two other ways, but each has a serious disadvantage. The first is the suncap — a very dense filter placed directly over the eyepiece. However, suncaps are dangerous: The filter lies where the light is concentrated, and terrific heat causes the filter to crack. There are far too many recorded cases where observers suffered permanent eye damage when a cracked suncap allowed the sun's full force to strike their eyes.

Obviously, if you let direct sunlight into your telescope, it is subjected to a great deal of heat. Whatever is used to cut the power of the sun is heated — as is the air inside the tube. Any change in temperature affects image definition. But once the temperature is stabilized, the telescope will work well — though perhaps without the same efficiency when used to view "colder" objects. *Caution: Do not use photographic film or polarizers to observe the sun; they do not screen out dangerous invisible radiation.*

A final alternative involves placing a partial aperture glass filter in front of the telescope and thus reducing the light before it enters the tube. These filters (usually expensive) are made of high quality glass with perfectly flat and parallel surfaces. Normally much smaller than the aperture of the telescope with which it is used, the filter has less resolving power than full aperture filters. Before the advent of inexpensive full aperture filters, the partial aperture filter was widely used.

What You Will See

Now that you're ready to do some solar observ-



This representation illustrates "differential rotation". The sun rotates faster at the equator. Therefore, if a series of sunspots could be lined up vertically on the sun's surface, those at the equator would speed ahead of those at higher and lower latitudes (after a few revolutions on the surface). This differential rotation occurs because the sun does not rotate as a solid body but as a gaseous sphere, fluid in nature. Artwork by Victor Costanzo.

ing, here's a note about the best time to do so. Unlike objects observed at night when the best time is as near the meridian as possible, the sun is best seen just after sunrise — before it gets 15 or 20 degrees above the horizon. Then the atmosphere is steady and clear — free of the dust and turbulence found later in the day.

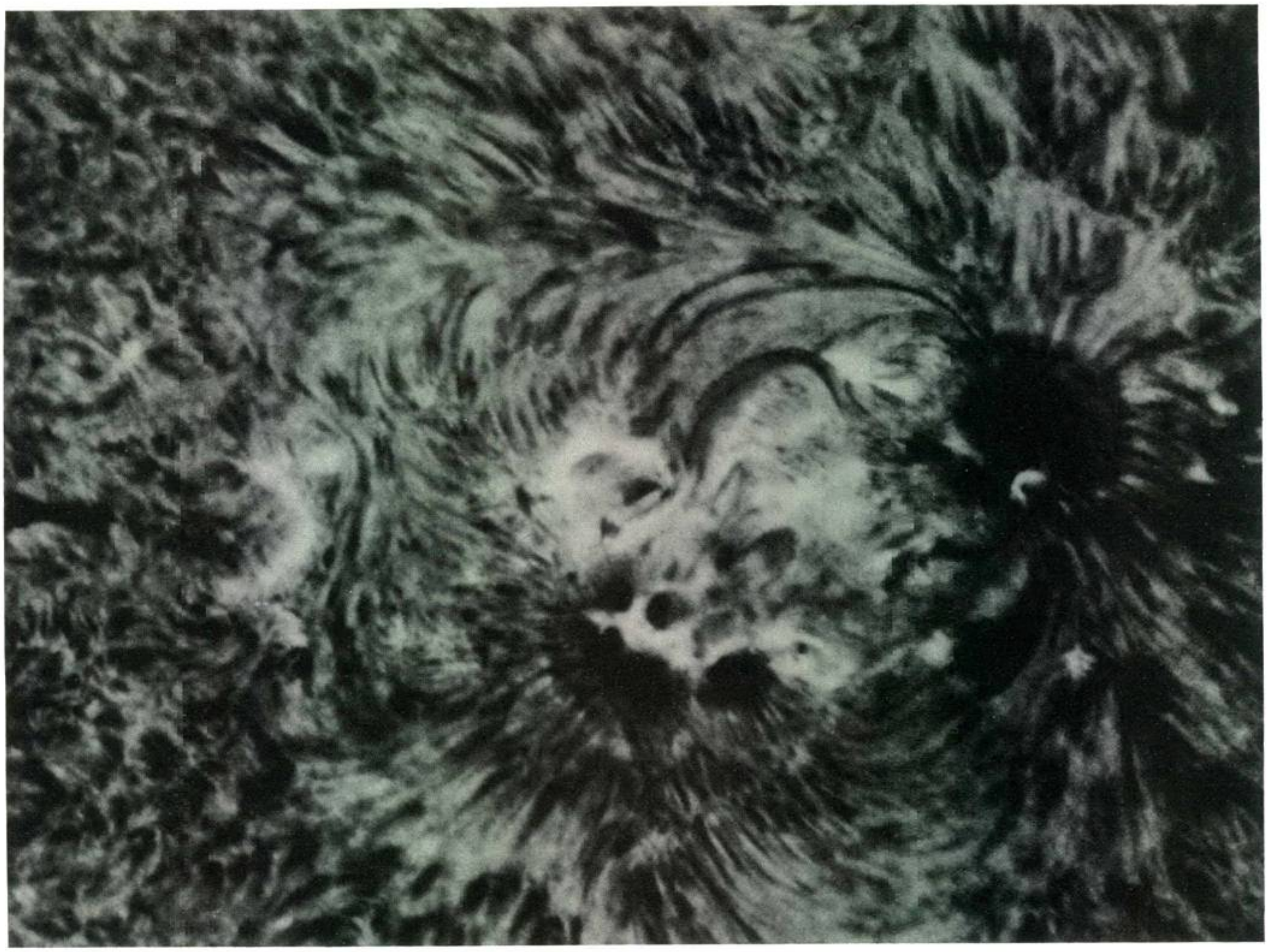
The sun is made of gases, and the part visible to us is the *photosphere* — an intensely bright region. Above the photosphere is the *chromosphere*, and outside it, the *corona*. Both are clearly visible only when observed through a coronograph, or when the sun is in total eclipse.

When you sharply focus the image of the sun, the first thing noticeable will be a black blotch or two on the surface (*sunspots*). The image also gets darker toward the edges or *limbs*. This is known as *limb darkening* (we can see farther into the photosphere at the center of the sun's disk than at the limb). You will probably also note the brilliant photosphere is not as smooth as it appears to be. Careful focusing should bring out a mottled or granular pattern on the surface. This is called *solar granulation*, and is probably best seen with the projected image — especially if you can cut down on the general ambient light with a dark blanket. If you're in doubt about its presence, tap the telescope lightly and the slight vibration of the image will bring out the pattern against the screen. The granules are rising clouds of gas — boiling much as water boils in a pot. They are quite large (some as large as the state of Kansas), and they change their appearance in a matter of minutes.

Other solar features that may be noticeable in the darkened areas toward the sun's limbs are extended, irregular bright patches known as *faculae*. They are clouds of hot, active hydrogen rising above the sun's surface. They are not generally visible near the center of the disk because of lack of contrast, but are associated with sunspots.

Perhaps the most fascinating and obvious feature on the surface of our star is sunspots. Early observers thought they were seeing solid objects between Earth and the sun, but after looking at them through his 32 power telescope, Galileo concluded they were located on the solar surface. The spots are not completely understood, but it is known they are some 2-3,000 degrees cooler than the solar surface.

Individual spots form, develop, decay and disappear in a matter of days or weeks. The frequency of the spots varies from periods when the disk is free of spots for days and weeks on end, to periods when the sun is always spotted with a number of groups scattered across its face. The period from one sunspot maximum to another is about 11 years — *the sunspot cycle*. Some variation takes place from cycle to cycle, and the rise to maximum is usually more rapid (3-1/2 to 4 years) than the drop to minimum (7 to 7-1/2 years). They appear most frequently in a region on the surface between 5 and 30 degrees north and south latitudes. With each new cycle rising from minimum, a few spots appear in the higher latitudes of both hemispheres. As the cycle progresses toward maximum, the spots get more frequent and appear increasingly nearer the



The sun can be a spectacular sight when seen in the narrow hydrogen-alpha wavelength, which shows detailed sunspots, faculae, prominences and granulation. This photo, taken through a Skyspear filter, shows the restless surface of the sun around an active sunspot. Viewing the sun through a hydrogen-alpha filter can add to an observer's pleasure as he watches changes on the sun's surface in a matter of minutes. Solar Research Photograph.

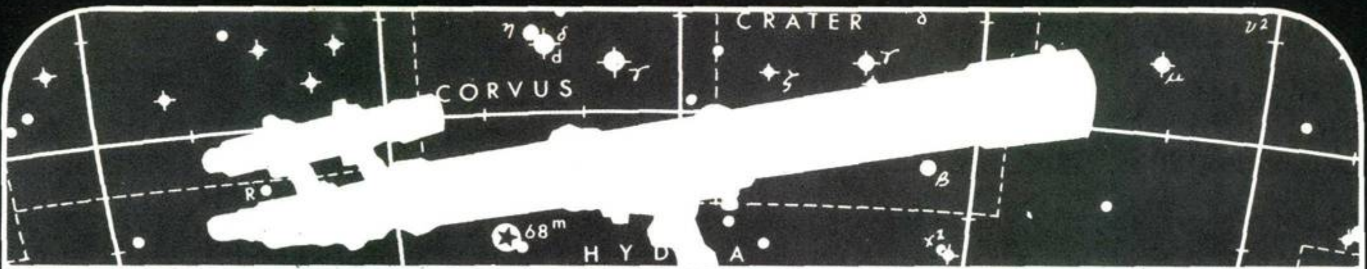
equator until at the maximum, the average latitude north and south is about 15 degrees. The spots appear stationary on the solar surface and can be used in determining solar rotation at various latitudes. Currently, the sun is near minimum of its sunspot cycle, but soon will begin producing more spots for viewing.

A relatively new advancement for the astronomy enthusiast who has access to telescopic equipment is a filter to observe the hydrogen-alpha image of the sun's surface. It allows observation and photography (if you wish) of *solar flares* (short-lived, but vigorous bursts of light on the sun's surface), *plages* (bright, ragged patches in the vicinity of sunspots), *prominences* (hydrogen "flames" exploding outward from the sun's edge) and *filaments*. The Skyspear filter (available from Solar Research, 17050 Chatsworth, Suite 242, Granada Hills, Calif. 91344) requires a restricting plate and heat absorbing filter over the telescope aperture to provide the right f-ratio through the filter and to prevent damage to the telescope from direct sunlight. The filter is relatively expensive but can provide far more spectacular views than normal "white light" viewing. Another less expensive hydrogen-alpha filter, the Solar Prominence Probe, is available from Roger W. Tuthill, 11 Tanglewood Ln., Box 1086A, Mountainside, N.J. 07092.

Eclipses

An awesome natural spectacle occurs when the sun is totally eclipsed by the moon, making the corona and chromosphere come into view. Most observers who also own camera equipment will want to preserve such an event as a rare and exciting celestial happening. Though there are many routes to take when photographing eclipses, *proper filtration is absolutely necessary.* (See ASTRONOMY, February 1974, and April and May 1975 for background material.) Eastman Kodak Company, 1343 State St., Rochester, N.Y. 14650 prints a unique booklet about choosing suitable film, exposure and techniques for which you can write for specifics.

The sun can be a fascinating and ever-changing subject for observation — providing you're a *cautious* and *safe observer.*

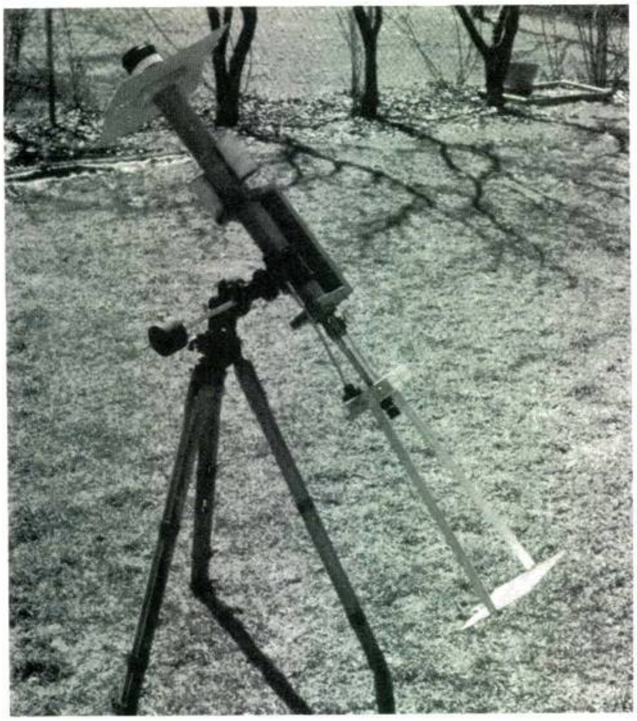


Solar Observing

Build a Projection Screen

Image projection is probably the simplest and definitely the safest way to observe the sun—if you do not have a solar filter that fits over your telescope objective. Equipment for observing the sun is easy to find for a small telescope, consisting of a cardboard shade slipped over the focusing tube, a stick (preferably a yardstick), masking tape and a piece of white cardboard upon which the sun's image is projected. Slight modification of your telescope may be necessary as well—particularly the eyepiece.

The sunshade for your telescope should be cut from a piece of cardboard large enough to shield the viewing screen from any extra light. Cut a

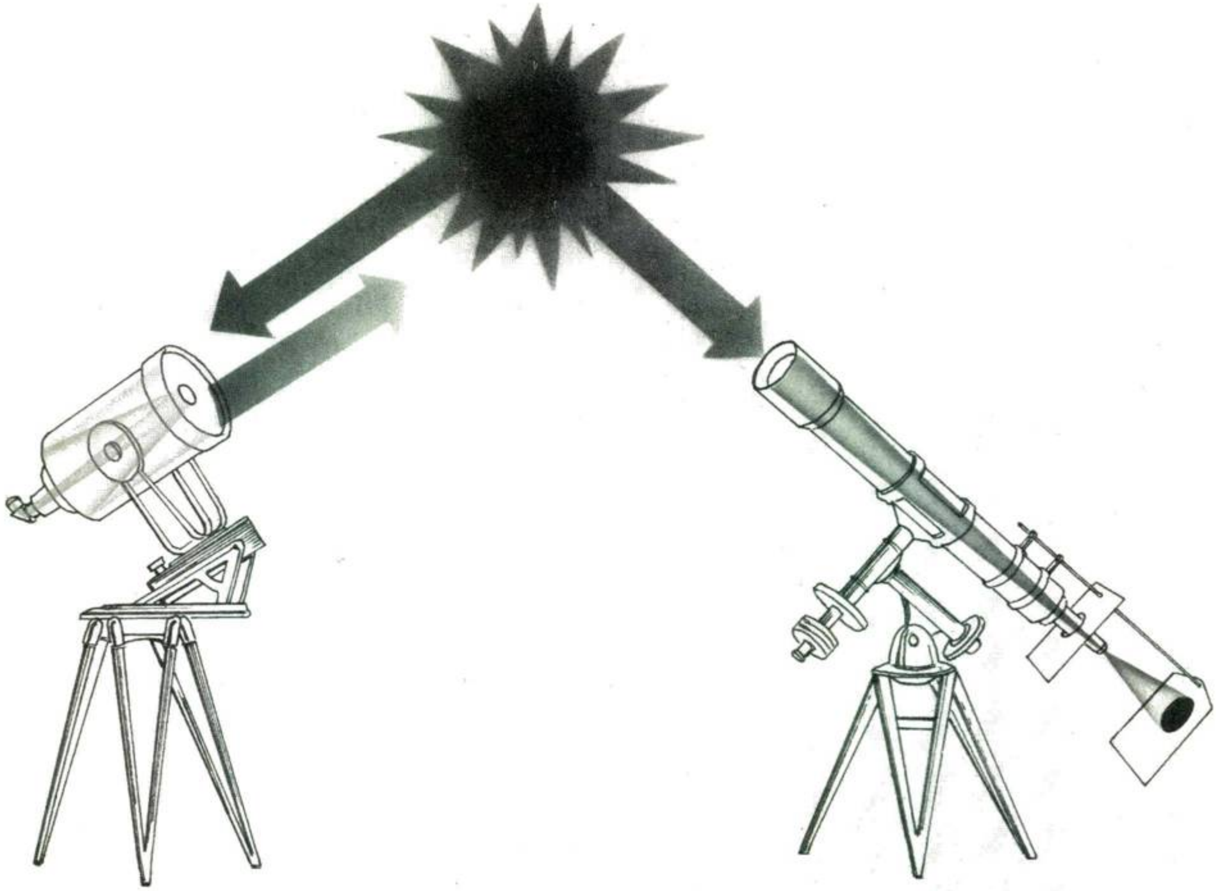


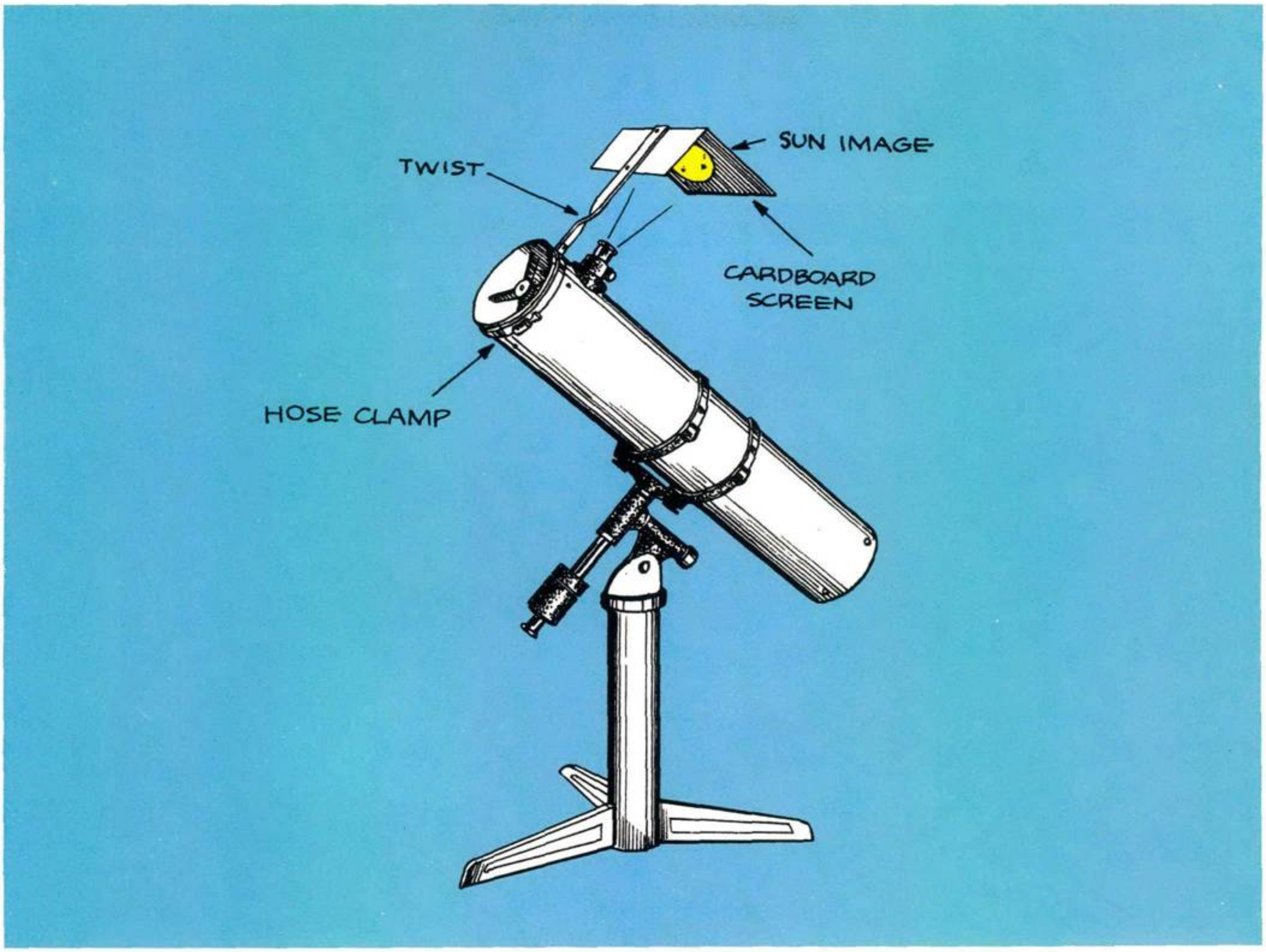
This solar observing setup for a refracting telescope is a slightly modified version of the one shown in the diagram also accompanying this article. The modifications best suited to your telescope and viewing pleasure are important. No single design can satisfy all needs, and the serious sun observer will improvise to produce the safest and most profitable solar observing setup. Photograph by Alan M. Pattee.

slit to the center of the cardboard and then make a hole large enough to fit snugly over the eyepiece extension tube at the end of the telescope. Tape it to the scope to prevent slipping. Next, position a stick at the bottom of the telescope and cut a small slit in the sun shield to accommodate it. Insert the stick through the hole beyond the eyepiece by four to six inches, and tape it to the scope by wrapping masking tape around it and the tube. Take a 7 x 9 inch piece of cardboard (flat white to show the best image), and fold up the extra two inches on one end, taping the two inch overhang to the yardstick securely. This is your solar observing screen.

When observing the sun, never use cemented eyepieces as the balsam used to cement the eyepiece together will melt under the concentrated heat of the sun's rays. Instead, use an inexpensive Huyghenian or Ramsden eyepiece of 1/2 to 1 inch focal length. Moderate magnifications are best for observing the sun, since they produce a complete disk on your projection screen.

Solar phenomena are best observed in relation to one another. With any setup using only a simple sunshade, the enlargement should be between 10 and 20 power. Too much enlargement makes the sun's projected disk too large and dim for daylight observing. Eyepieces should be clean since any dirt on them will show up more or less in focus on the image. Before getting excited over a new





Another version of solar projection, this time for a Newtonian reflector, is shown here. Easily and cheaply built, this lightweight projection screen can offer hours of pleasurable solar observing. Artwork by Victor Costanzo.

solar discovery, try rotating the eyepiece—a real sunspot will stand still.

You can find the sun by adjusting the telescope tube until it makes the smallest possible shadow on the ground. The sun must now be nearly centered in the telescope and probably only slight adjustment will be needed to bring the image on the screen. Don't sight along the telescope tube, and if your scope has a finder, remove it completely or put a cap over it. The sun's concentrated glare is dangerous to the human eye and can cause permanent damage—even partial blindness—if caution is not used.

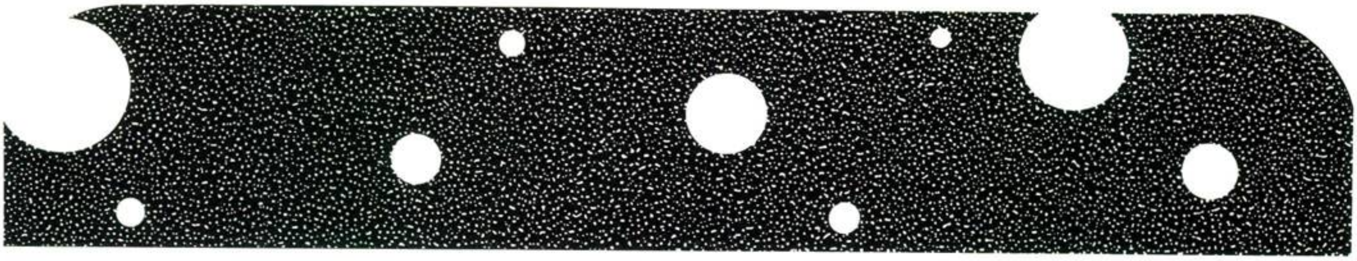
The distance from the eyepiece to the screen is best left to trial and error, as it varies with the eyepiece used and the image size desired. Adjust the focus by moving the eyepiece until the image of the sun's limb edge looks sharp and clear. Focusing at the beginning of the observing session may be difficult because the sun's heat changes the curves in the optical system.

This diagram reveals the principles involved when observing the sun through a solar filter (right) and by projection (left). The solar filter reflects 99.999 percent of the light, keeping the telescope optics cool and the eye safely protected. In projection, heat and light pass down the tube of the refracting telescope, focusing on a white screen several inches away from a noncemented eyepiece. Note the finderscopes have been removed on both telescopes to prevent any possible danger from the sun's concentrated heat. Artwork by Victor Costanzo.

This simple viewing setup requires everyday items, is quick to construct, and offers relatively safe sun observation. It is also lightweight, and will not generally overbalance a telescope tube.

The setup for a Newtonian with the side eyepiece mount is slightly different, but equally simple to build and enjoy. In this case, a metal hose clamp large enough to fit over the end of the Newtonian tube is necessary. It should have a one foot metal extension allowing you to fasten both the sunshield and projection screen as illustrated. Again, use noncemented eyepieces. The focusing and sighting-the-sun procedures remain the same.

These are only two examples for solar observing setups. Modifications are possible for your own telescope, and the creative solar observer will come up with the best method for his or her own equipment.



Cosmic Rays

by
Gerrit L. Verschuur

Cosmic rays permeate all of space around us, traveling between stars and through interplanetary space, as well as crashing into Earth's atmosphere. They are the basic building blocks of matter traveling at near the speed of light. Starting their journeys in cataclysmic explosions of stars (supernovae), the electrons, protons and heavier ions (nuclei of atoms other than hydrogen) are hurled outward into space. Sensing the magnetic fields threading nebular remains of supernovae, cosmic rays are catapulted out to interstellar space. When some of these cosmic rays reach Earth they collide with atoms and molecules in the atmosphere, causing showers of fragmented materials to cascade down to Earth's surface.

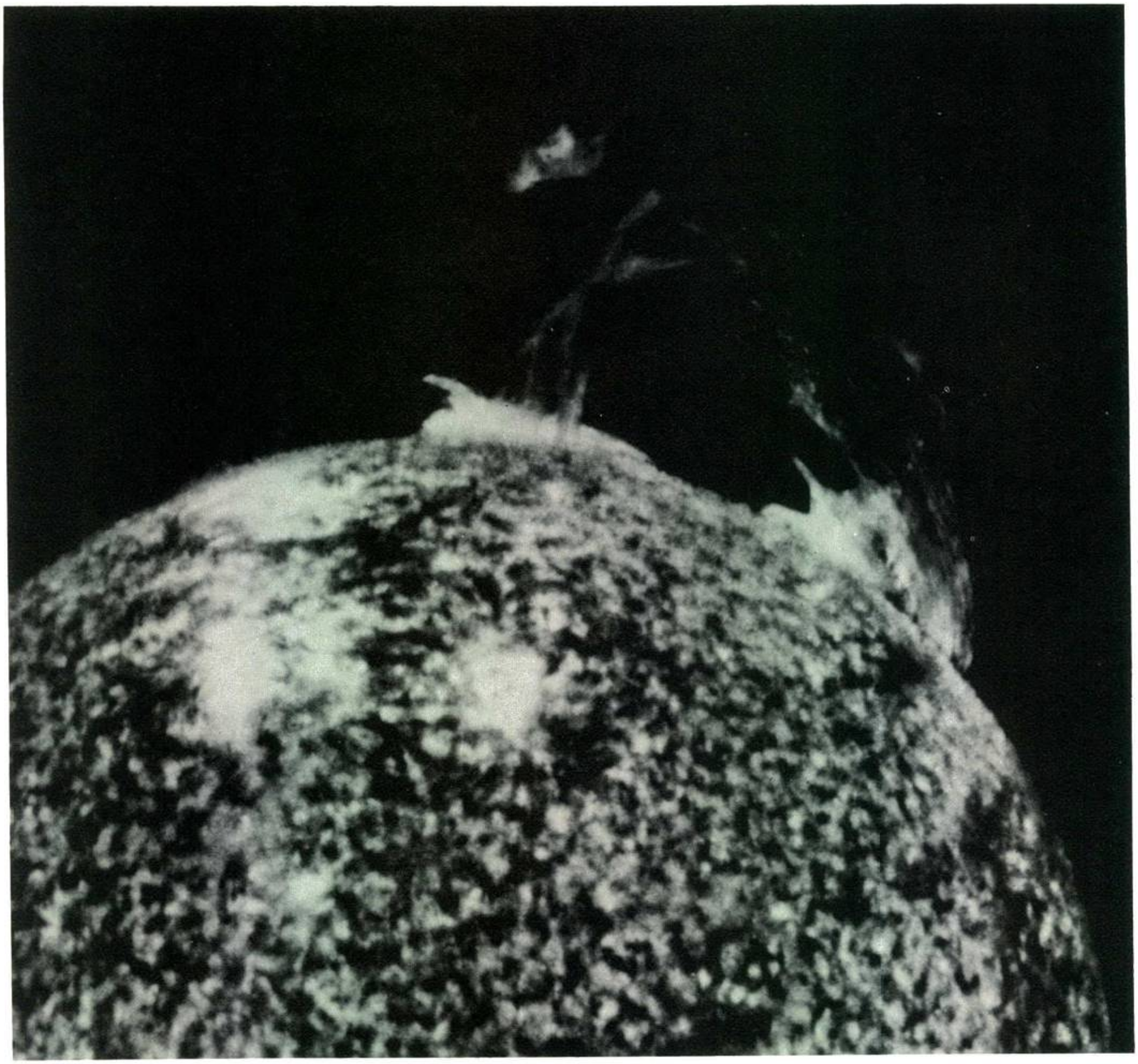
Besides the cosmic rays that originate in stellar explosions, there are less energetic rays originating in small solar explosions called *flares*. Solar flares send clouds of particles out into the solar system.

Few events in the universe match a supernova's violence and energy output. When a massive star finally exhausts its nuclear fuel, the remaining matter quickly collapses upon itself. Internal pressures soon trigger an explosion, blasting incredible amounts of stellar material back into space. Accelerated to near light speeds, individual protons, neutrons, and heavier atomic nuclei streak away from the supernova as cosmic rays. Earth is continuously bombarded by these remnants of star death. Artwork by Adolf Schaller.

Earth's magnetic field effectively acts as a shield to the solar cosmic rays. It deflects the rays, forcing them along new paths into space or trapping the particles so they spiral — corkscrew fashion — back and forth along the field lines for years. These trapped particles form the Van Allen radiation belts of Earth. However, when the dose of cosmic rays emitted by a flare is too great for the field to handle, some of the cosmic rays plunge down the magnetic fields — leaking into the atmosphere near Earth's magnetic poles, generating the well-known aurorae.

Cosmic rays from outside our solar system primarily come from supernovae and appear to be reaching us from all directions in space — although recent observations suggest three preferred arrival directions for the rays (see Astro-News, July 1975). Since their arrival directions are nearly uniform, possibly some mechanism diffuses their paths through space.

When the cosmic ray electrons — traveling at near the speed of light — encounter a magnetic



A Skylab photograph of the sun reveals one of the most spectacular solar flares ever recorded — a bridge of gas spanning 367,000 miles of solar surface. Such explosive events on the sun launch barrages of high energy particles earthward. Fortunately, our planet's magnetic field traps most of these cosmic rays, forming the Van Allen radiation belt. NASA photograph.

field, they are forced to spiral about it. When following a magnetic field, the cosmic rays release some of their energy as radio waves. This process of radio emission by cosmic rays is called *synchrotron radiation*, since the phenomenon was first observed near particle accelerators called synchrotrons. In these devices, electrons are accelerated close to the speed of light and forced to move along magnetic fields. Consequently, the particles generate a lot of radio noise.

Cosmic ray electrons are easily affected by magnetic fields, but the heavier protons move much more sluggishly and do not strongly react to a magnetic field. This means they more readily crash into Earth's atmosphere — interacting with matter and shattering atoms and molecules in the atmosphere. Cosmic rays tear electrons out of their orbits and cause great showers of so-called *secondary* electrons which cascade toward our planet's surface.

Since the consequence of such atom shattering collisions is an abundance of electrons and ionized atoms, the air around us is always filled with electricity. When this was first discovered in 1900, the cause of ionization was not understood. Balloon flights showed electrical charges increase at altitudes above 2,000 feet, suggesting the source must be high in the atmosphere. Since there was no preferred direction for the ionization source and it appeared to be constant (day and night), scientists realized the cause had to be of cosmic origin. Hence the name cosmic rays was coined. Later experiments showed cosmic rays must be the basic nuclei of atoms — in particular the hydrogen atom (whose nucleus is the proton).

Cosmic rays have an important bearing on our knowledge of space. The fact that they appear to be approaching us equally from all directions was one of the first proofs that magnetic fields exist between the stars. Knowing that the cosmic rays are trapped in the galactic magnetic field of the Milky Way galaxy, we can estimate the field's strength. Although 100,000 times weaker than Earth's field, the interstellar magnetic field possibly screens our galaxy from cosmic rays reaching it from distant galaxies and quasars.

Cosmic rays also allow scientists to determine the ages of early rocks and meteorites. This is made possible by an interesting series of events. Cosmic ray collisions with atoms high in the atmosphere release many neutrons (the nuclei of the heavier atoms). They, in turn, hit atmospheric atoms such as nitrogen. The neutrons combine with nitrogen atoms to make the isotope carbon-14 (C^{14}). Ultimately this radioactive carbon becomes part of carbon dioxide, which is absorbed by plant and animal life. The amount of C^{14} in any body decreases by half every 5,700 years, so scientists calculate the age of substances by measuring how much radioactive carbon is left. The relative amounts present in any sample indicate how many years C^{14} has been decaying.

Recently, the cosmic ray role in damaging Earth's atmosphere has received attention. Cosmic rays produce nitrogen oxides which in turn destroy ozone in the upper atmosphere. An ozone layer at 20 miles altitude shields us from most of the sun's ultraviolet light. If the cosmic ray dose reaching Earth dramatically increased (if a nearby star exploded), then the ozone layer might be almost entirely removed by increased production of nitrogen oxides.

Cosmic rays are constantly passing through our bodies — even though most of them are secondary particles produced by collisions with matter high in the atmosphere. These secondary particles can shatter molecules in our bodies, but this occurs on a very small scale. Little is known about the cumulative effects of cosmic ray bombardment, except that exposure to high doses of cosmic rays for any length of time is lethal. Regions of space where such doses would occur include the radiation belts of Jupiter, where cosmic rays are trapped in large numbers and emit strong radio signals. Earth has similar belts of trapped particles but their numbers and energy are not great enough to harm astronauts.

Cosmic rays may sound like a weapon created by a science fiction author. Fortunately they do not pose a direct threat to us, but carry messages about the death of stars thousands of light-years away.

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ASTRONOMY is seeking to enlarge its Milwaukee editorial staff by the end of 1975. The positions to be filled are for content writers/editors which require combined ability to write and knowledge of astronomy as outlined below.

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To qualify for current editorial openings, applicants must be knowledgeable in one or both of the following areas:

A. Well-versed knowledge or education in descriptive astronomy, current astronomical research and space science, with a thorough comprehension of the physical appearance, behavior and nature of mathematical or theoretical concepts such as black holes, quasars, neutron stars, etc.

B. Accumulated knowledge and experience with practical astronomy including the full gamut of amateur observing, use of telescopes and other astronomical equipment, possibly equipment building, astrophotography - all activities of interest to the practicing astronomy enthusiast.

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A. Journalism or communication education, courses or degree emphasizing magazine writing, editing, layout and design.

B. Experience as a writer/editor for major media. (Writing a local "club" newsletter probably will not qualify you.)

C. Proven experience/ability as a free lance writer.

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ASTRO-NEWS

Latest News From the World of Astronomy

Radar Probes Ganymede

Jupiter's largest satellite, Ganymede, has a surface considerably rougher than Mercury, Mars or Venus according to recent radar probes.

The Ganymede test, conducted over a distance of 380 million miles, used the 210 foot antenna at the Goldstone, Calif. tracking station.

Dr. Richard Goldstein and co-investigator George A. Morris said of the first radar probing of another planet's satellite: "Perhaps the most likely possibility for the surface of Ganymede is rocky and/or metallic material embedded in a matrix of ice. Such a surface could be relatively smooth, with a top layer of ice rubble — but it could be rough to radar since the ice would be transparent."

In contrast, the Pioneer 10 and 11 flybys verified that Jupiter itself is gaseous with no solid surface able to sustain a radar echo.

Ganymede's material probably is meteoritic in origin. Only one other celestial body — a small asteroid named Toro — has appeared rough to radar scans. Roughness was evident from echoes detected away from the disk center, as rough disks reflect echoes from the entire surface.

Craggy as Ganymede may be, radar was unable to pick out craters because of the distance. A recent Pioneer 11 photograph of Ganymede showed apparent craters and two mares, perhaps like those on Earth's moon.

One of the four large Jovian satellites discovered by Galileo, Ganymede is slightly larger than the planet Mercury. It revolves around Jupiter once every 7.15 days.

Optical astronomers have believed Ganymede's brightness indicates a largely icy composition (infrared spectra suggests water ice). A simple ice sphere, however, does not fit the radar data. A rocky surface coated by frost or thin ice could be possible, but a mixed rock/metal and ice surface is more likely.

Although 13 moons circle Jupiter, the precomputed orbital data proved so exact the radar astronomers were able to draw a bead on Ganymede in its orbit about 625,000 miles from Jupiter without hitting another satellite. In the past decade the same radar astronomy team has repeatedly probed and partially mapped the topography of the inner planets. Their outermost probe to date was a radar bounce off Saturn's rings — a 1.5 billion mile round trip.

Soviets Suggest Planet Past Pluto

At least one undiscovered planet the size of Earth exists beyond Pluto, according to Soviet astronomers.

Mathematical analysis of comets observed in the last century shows the planet is 54 times farther away from the sun than Earth.

Further Soviet analysis of a comet family indicates that another planet, also about the size of our planet, may exist 100 times more distant from the sun than Earth.

Long-Term Forecast Given

Prediction of long-term climatic changes on Earth has generally been regarded as a terrestrial problem and most recently involved the gloomy speculation of an imminent Ice Age. But W. H. McCrea of Sussex University in England brings an astronomer's grasp of big time and big distances to the terrestrial Ice Age problem. Rather than citing changes on Earth as the cause of Ice Ages, he looks at the solar system's place in the galaxy.

There is, according to McCrea, geological evidence indicating that ice cover occurred on Earth at roughly 250 million year intervals. Each ice epoch lasted a few million years, during which conditions varied between extreme glaciation and milder interglacial periods (like the present day).

The "period" between ice epochs is just half the time it takes the solar system to make one orbit around the Milky Way galaxy (about 500 million years). A previous generation of astronomers had already noted this. McCrea says this must be more than coincidence and relates the effect to the spiral structure of the galaxy.

Spiral arms are a common feature seen in galaxies much like our own. Along the edges of the spiral arms are dark lanes of dust and gas. When the solar system moves around its orbit, it crosses each of the spiral arms once in a 500 million year orbit, and runs into a dust lane every 250 million years or so.

The immediate result is a warming of the sun's surface layers as it takes on dust. Paradoxically, the sun's warming may cause an Ice Age to set in on Earth, for the slightly higher solar output could increase cloud cover on the planet. Although more heat would be reaching Earth, the increased cloud cover would also reflect considerable heat away.

McCrea's model stands up under numerical calculations for the effect of the dust striking the sun. It also explains our present situation in a straightforward manner.

The solar syslem is presently on the edge of a galactic spiral arm (the Orion arm), having emerged from the associated dust and gas lanes about 10,000 years ago. The time we left the dust corresponds to the end of the most recent intense glaciation period (which ended some 10 millennia ago). If McCrea's ideas are correct, the weather should be fair for the next 250 million years — until the solar system enters the other spiral arm.

Lunar Dust Storms Discovered

In one of those rare, fortunate accidents sprinkled through the history of science, a major new discovery is emerging from the "failure" of a lunar experiment. Placed in the moon's mountainous Taurus-Littrow region by the 1973 Apollo 17 expedition, the Lunar Ejecta and Meteor Experiment (LEAM) was originally intended to look for debris from new meteorite impacts and deep space dust colliding with the moon. Experimenters Otto Berg, Frank Richardson, John Rhee and Siegfried Auer of Goddard Space Flight Center predicted that about one interplanetary particle per day would strike LEAM. Instead, the instrument soon started acting berserk, reporting many impacts per *hour* during lunar sunrise and sunset.

"For the first few months we were convinced that the experiment was responding to high temperatures, and we were pretty disappointed," says Berg. "But more and more it became apparent that there was particle movement in a particular direction, and that temperatures had nothing to do with it since high activity started 30 to 60 hours before sunrise." The experimenters conclude that they were observing lunar dust storms!

Berg emphasizes that this phenomena is likely an important erosional process on the moon and best explains how a thin dust layer was deposited over the lava-filled lunar seas or maria. Until now meteorite impacts have been the only known process for transporting lunar material, and impacts just explain how large boulders — not dust — got shuffled around our satellite.

However, the mechanism behind the dust storm remains far from being fully understood and is quite complex, involving charged particles, changing electric fields and ionizing radiation. It seems that half the moon is always carrying a positive electrostatic charge, and the other half a negative charge. On the moon's sunlit side, solar energy breaks up surface atoms, creating a surplus of electrons or a positive charge. Meanwhile on the dark side, electrons are easily absorbed into the surface, imparting a negative charge. Very tiny particles loosely scattered on the sunlit side also take on a positive charge until the repulsive force between the like charges on the overall surface and the dust specks builds up to a point where they shoot off like microscopic bullets. Berg estimates that a particle could go hopping along the moon for 1,000 miles at 1,500 to 3,000 foot altitudes.

The highest amount of particle activity occurs at the boundary between the day and night side — the lunar terminator. Near the terminator, positively charged dust particles are strongly attracted into the negatively charged dark side. In these "storms", the dust accelerates to velocities high enough to launch it halfway around the moon.

Mysteriously, there is not yet any strong evidence favoring a reverse "wind" of negatively charged dust streaming into the sunlit side. In addition, a much more intense dust storm accompanies sunrise than sunset. Berg believes that the trajectory the solar wind follows near the moon gives dark side terrain within 100 miles of the morning terminator an especially high negative potential.

Has anyone ever directly observed lunar dust storms? At least one astronaut, Eugene Cernan on Apollo 10, reported seeing flares of light along the sunrise terminator. Some scientists have interpreted this as possible evidence for dust movement, Berg points out. However he argues that the dust storms are so tenuous that an astronaut even on the lunar surface at sunrise probably would not notice anything unusual.

For the next several years, the nuclear powered LEAM should continue sensing the periodic dust storms — providing the Goddard team with increasing data about this unusual type of planetary erosion.

Orbiting Solar Observatory Begins Extensive Study

A better understanding of energy transfer in the sun's hot, gaseous atmosphere and a continuing study of the sun's 11 year sunspot cycle are the objectives of the recently launched Orbiting Solar Observatory — the eighth and last of the OSO series.

From the satellite's circular 343 mile orbit, American and French ultraviolet telescopes with focal lengths up to 10 feet will be trained on the sun to investigate the methods by which solar energy is transferred between layers of the sun's atmosphere. The observation is a followup on clues revealed by astronaut-operated solar observation equipment on Skylab.

OSO-8 is larger and more sophisticated than previous OSO spacecraft which have observed the sun over an entire solar cycle since the launch of OSO-1 in March 1962. OSO-8 weighs 2,346 pounds, compared to 440 pounds for OSO-1.

A secondary objective of OSO-8 is to investigate celestial sources of X-rays in the Milky Way galaxy and beyond. The most elaborate selection of cosmic X-ray telescopes yet launched is being used to investigate the mysterious X-ray background radiation that appears to be arriving at Earth from all directions in space. Scientists will attempt to determine conclusively whether the radiation comes from the nearby surroundings of our Milky Way galaxy or from the distant reaches of space.

In addition, the X-ray telescopes will be aimed at more than 102 preselected objects of special interest to astronomers. They will observe supernova remnants (the hot expanding clouds of cosmic debris that result from the explosive disruption of dying stars) to determine their physical and chemical composition, as well as search for pulsars within the clouds.

OSO-8 will also observe "X-ray binaries" that seem to consist of a visible star and a small invisible companion — which may be a highly condensed neutron star or possibly a black hole. (A black hole is believed to form when a shrinking star's gravitational field intensifies to the point that no light or matter can ever escape from the object.)

Past experience with the Uhuru and OSO-7 satellites suggests that the more sensitive equipment on OSO-8 will discover new X-ray sources in space, which may prove to be of even greater interest than those which are already under study.

Increased knowledge of the sun is desirable not only because it is the ultimate source of energy supporting all life on Earth, but also because it is the closest nearby star for astronomers and physicists to study in detail. The sun is a laboratory where temperatures, pressures and magnetic field intensities can be studied at magnitudes impossible to achieve on Earth. In addition, there is abundant evidence

Observatory *continued on page 60*

Astronomers Tackle Job Decline By Discouraging Grad Students

New Ph.D's in astronomy still have difficulty finding jobs. Yet the ranks of astronomy graduate students are growing rapidly, according to the National Academy of Sciences. Their Astronomy Manpower Committee advised the production of new Ph.D's be reduced.

Based on current enrollment figures and employment trends, the committee estimates during the next five years at least 600 new astronomy Ph.D's will enter the field, competing for only 50 to 100 openings available through retirement. At most, the report says, 200 openings would be available.

In an unusual move, the committee recommended the following letter be sent to all prospective astronomy students:

"Dear Student:

"Traditionally, the most desirable positions for a young astronomer have been those at large universities or major observatories where one could devote a substantial fraction of time to research. However, the increased numbers of graduate students in the physical sciences, the overall decreased enrollment at the undergraduate levels, and the decreased funds available for research have combined to make the prospect of obtaining such positions increasingly difficult. Opportunities will be available, of course, but the ratio of candidates to available positions at current rates of Ph.D production is projected to be more than four to one.

"You should now seriously consider whether your interest in the field is so great that you wish to devote five more years of hard study to astronomy, knowing that at the end of those years the main job openings will probably be in fields entirely different from astronomy.

"With the subject matter of the physical sciences changing so rapidly, it is not uncommon for a person who acquires knowledge and research experience in one field to change later to an allied one. The positions which will be available to you will be filled on a highly competitive basis, and you must be very honest with yourself in assessing your chances of success not only for completion of the Ph.D but also in the competition for employment. We will do everything possible to advise you carefully as to your chances for future success in both graduate school and your intended career."

The committee, faced with what to do with extra astronomers, proposed the following:

— University departments granting Ph.D's in astronomy and astrophysics should reduce their Ph.D production by informing students of employment problems and provide programs broad enough to offer students mobility in the job market.

— Regular faculty members in astronomy departments should assume more undergraduate teaching responsibilities now handled by graduate students to fill the need created by reduced graduate enrollments.

— Astronomy and physics departments together should develop graduate programs designed to make the Ph.D astronomer more attractive to small colleges and especially industry, which now employs a much smaller percentage of astronomers than physicists.

— The American Astronomical Society should lead an effort to expand existing undergraduate astronomy programs and introduce them where they are not offered to create openings for new astronomers.

— All centers of astronomical research should establish ways to collaborate in research carried out in more isolated locations.

— State legislatures should be encouraged to incorporate an astronomy course as a science credit for all new and continuing education students and teachers to increase teaching opportunities for astronomers.

— NASA should examine the need for data analysis from space missions (one research area that has suffered from cutbacks in federal funding) in an attempt to create more job opportunities.

Soviets Launch Venus Probes

In June, the Soviet Union's Veneras 9 and 10 were sent on their way toward an October rendezvous with cloud-covered Venus.

At least five times, Soviet space probes have reached the surface of Venus. Only the latest two — Venera 7 (1970) and Venera 8 (1972) — were still sending signals when they touched down.

Though no landing attempt has been suggested, past Soviet Venus probes have done so. The craft were described by the Soviets as "a new type of spacecraft for the exploration of Venus", but they announced no details.

During their flight from Earth, Veneras 9 and 10 will report on the solar wind, interplanetary magnetic field and ultraviolet radiation. If one or both land, they will probably measure the atmospheric temperature, pressure, composition and winds, as well as surface composition of Venus.

Apparently Veneras 4, 5 and 6 were disabled before they reached the surface. Venera 7 lasted 23 minutes on Dec. 15, 1970. It transmitted data indicating a surface temperature of 920 degrees Fahrenheit, and an atmospheric pressure 90 times that of Earth. Venera 8's surface lifetime — about 50 minutes on July 22, 1972 — generally confirmed the previous temperature and pressure data and added the finding of surface rock containing slightly higher amounts of uranium, thorium, and potassium than Earth's basalt.

The United States has never tried a Venus landing. Mariners 2, 5 and 10 flew by the planet, with Mariner 10 providing photographs of Venusian cloud structure. But not even the Pioneer Venus mission being readied for 1978 is planned to produce a soft landing. The mission will include one spacecraft that orbits the planet, while a "carrier" probe will send three smaller craft (plus itself) in through the atmosphere to take measurements all the way down to a "nonsurvivable landing".

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Old Photos Trace Quasar Evolution

An astronomer has traced the life cycle of quasars with the aid of photographs made almost a century before these mysterious starlike objects were discovered.

Dr. Peter D. Usher of Pennsylvania State University believes that quasars are actually distant compact galaxies in the throes of gravitational collapse.

Usher and his graduate students used what they call the "Harvard Time Machine" for the study. The term refers to a collection of more than half a million photographs taken at the Harvard Observatories since the late 1800s. Originally made for a study of variable stars in our galaxy, the photographs also caught extragalactic objects — providing a ready made long-term record of quasar behavior.

Usher says that most quasars look like variable stars that emit strong radio signals. But they emit more radiation than any star could — "more than 19 trillion times the amount of our sun, or about 100 times the total amount of starlight emitted by all the stars in our galaxy."

To compound the paradox, Usher says, "Some quasars vary rapidly in brightness, indicating that they are extremely small — perhaps as small as the solar system."

In addition, so-called "normal" quasars emit light with distinctive spectral line patterns, while others — which Usher calls QC sources — are continuous or featureless.

Two years ago, Usher and David Hall (a graduate student) suggested that among the QC sources those that vary the most in brightness would also have the most unusual radio emission. That suggestion was confirmed last summer by another of Usher's graduate students, Joseph Pollack, using the "Time Machine".

Now Usher has extended the QC relationship to cover other types of quasars and has shown that it provides an insight into their evolution and nature. He says, "The data suggest that quasars start their life cycle as normal elliptical galaxies. Then something catastrophic happens and a cataclysmic release of energy begins in the center of the galaxy. The galaxy soon becomes a QC source, progresses to a normal quasar, and eventually ends up as a radio galaxy."

According to Usher, gravitational collapse is probably the driving force of their evolution, "because no other reasonable progress can account for such a large release of energy. It amounts to a chunk of matter like the sun being annihilated every year — not burned, but totally annihilated into pure energy."

Usher notes that astronomers have speculated that the final stage of quasar evolution might be a black hole, an object whose gravity is so strong that neither light nor any other form of radiation can escape or even pass by without being trapped.

In addition to wondering what quasars are, astronomers have also been puzzling over where they are. Some astronomers say that they are formed at the fringes of the universe while others argue that the objects appear to be too small to produce as much energy as they do and still be at great distances from Earth.

Usher has applied a standard test for an expanding universe to the new data, and the results support the position that quasars are distant objects. The finding carries with it the implication that astronomers must now show whether gravitational collapse can account for the quasar's large energy output.

"The quasars are trying to tell us something," Usher says. "Whatever that message is, it is likely to change some fundamental ideas in astronomy and physics. For example, if quasars should turn out to be unusually massive, it could mean that the universe is dense enough to provide sufficiently strong mutual gravitational attraction to reverse any expansion. In that case, we would be living in a universe which is itself a huge black hole."

Observatory

continued from page 58

that the sun affects Earth's weather and climate, but the precise mechanism is not clearly understood.

Since the beginning of the OSO program, significant scientific information has been gathered by the solar observatories. Among the discoveries made by scientists from studying OSO data are:

An increase in *soft X-ray emissions* that often precedes an impending solar flare by up to several minutes. (It takes 8-1/2 minutes for solar radiation to travel from the sun to Earth.)

Solar flares — the sudden release of tremendous energy and material from the sun — have temperatures above 30 million degrees. (A flare may last minutes or hours and may release as much energy as the whole world uses in 100,000 years.)

Solar polar caps have temperatures of about one million degrees Celsius (1.8 million degrees Fahrenheit), compared to other parts of the solar corona which register about two million degrees Celsius (3.6 million degrees Fahrenheit).

Coronal holes, where temperatures are much lower than average, seem to be distinct from the solar polar caps — although they do have many similar characteristics. The polar caps and holes may provide new clues to the sun's interior.

Enormous eruptions of material from the sun's outer corona — events that had not been recognized throughout some 100 years of scientific eclipse observations. Similar eruptions that reshaped solar magnetic fields and coronal structure were observed by Skylab in 1973 to confirm this discovery.

The measurement of highly accurate positions for several X-ray sources which later permitted them to be identified visually. Such measurements may provide new clues as to whether black holes exist.

High energy gamma rays that are coming from a source in the middle of our galaxy.

"Professor, there's an inscription on this Moonstone. It says: 'Made in Japan'".

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FOR SALE — Questar standard 3-1/2" with Cer-Vit mirror, wide field, broad band and low reflection coating. Also special Questar accessories. All in excellent condition. New, $2,756.88; will sell for $2,200.00. Write Marlin Cilz, Box 839, Malta, MT 59538.

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FOR SALE — 6" f/8 Newtonian reflector with setting circles, 2 eyepieces (20mm, 4mm Ramsden), heavy duty equatorial mount. Heavy cardboard tube in good condition. Price: $115.00 certified plus shipping. Contact Harry E. Lewis, 414 E. Superior, Jacksonville, IL 62650. Phone (217) 243-4848.

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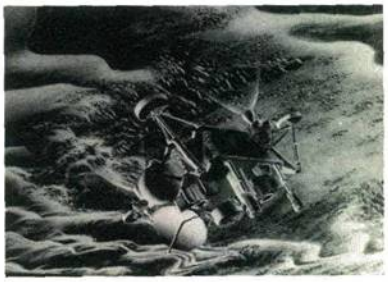

The Viking lander begins its powered descent 5,000 feet above the Cydonia region of Mars. From Set Twelve: Project Viking.

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FOR SALE — 6" reflector with Edmund heavy duty equatorial mount, 1/10 wave University Optic's mirror with 2 orthoscopic and 2 Kellner eyepieces. Very good condition. Price: $175.00 plus shipping. Contact Robert M. Penland, 1305 Parkington Ln., Bowie, MD 20716. Phone (301) 249-6293.

FOR SALE — Cave 6" Newtonian reflector with clock drive, setting circles, mount, 8 x 50 finderscope, 3 eyepieces. One year old; new, $335.00. Price: $235.00. Contact George Morrera, 17830 Sherman Way, Reseda, CA 91335. Phone (213) 344-1938.

FOR SALE — 10x-30x (30mm) telescope and tripod. Excellent condition; $10.00. Also plans for building time capsule for use in biology or physics; $6.00. Write Eugene Savage, 1632 Seminole St., Flint, MI 48503.

FOR SALE — Edmund 6" f/8 reflector with 3 eyepieces, Barlow, erector lens. Very good condition. Price: $150.00 plus shipping. Contact John Newman, 312 Brook St., Moscow, PA 18444. Phone (717) 842-2281.

FOR SALE — 4" Unitron refractor with tripod, altazimuth mount, Unihex, 6 eyepieces, Herschel wedge, wooden cabinets. Perfect condition. Price: $350.00. Contact Stephen Lewis, 209 Garces Dr., San Francisco, CA 94132. Phone (415) 334-8323.

FOR SALE — 16" Newtonian reflector with massive fork mount and mirror of low-expansion glass (needs repolishing). Price: best offer over $700.00. Write Roy L. Stout, Midsouth Astronomical Research Society, P.O. Box 4192, North Little Rock, AR 72116.

FOR SALE — Criterion RV-6 f/8 Dynascope with equatorial mount, setting circles, clock drive, all-metal tripod, 3 Achromatic Ramsden eyepieces. One year old, seldom used; excellent condition. Price: $185.00 plus shipping. Contact Joseph P. Turkowski, 8719 Gaskin Rd., Baldwinsville, NY 13027. Phone (315) 695-6819.

FOR SALE — 16" f/6 Newtonian mounted on 4-wheel trailer; solid equatorial mount, drive, circles, electric slow motions (both axes), guidescope, rotating tube, other accessories. Will sacrifice for $3,000.00. Contact Joel A. Slagg, 3410 Crane Creek Rd., Boise, ID 83702. Phone (208) 384-6100 days; (208) 344-3913 evenings and weekends.

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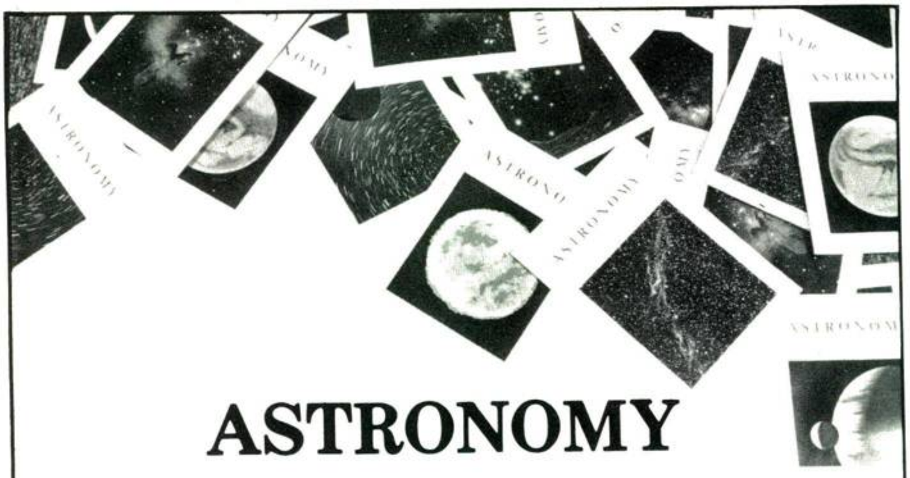

ASTRONOMY

Guide to Back Issues

Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. The following back issues are depleted: September, October, November, December 1973; January, February, May, August, October, December 1974; March and April 1975.

Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly, and completely revised about every six months. While they last, back issues are available for the cover price of $1.50 each (price includes postage).

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

Vol. 1, No. 1 - August 1973	**Available**	**Vol. 3, No. 7 - July 1975**	**Available**
Vol. 2, No. 3 - March 1974	**Available**	**Vol. 3, No. 8 - August 1975**	**Available**
Vol. 2, No. 4 - April 1974	**Short Supply**	**Vol. 3, No. 9 - September 1975**	**Available**
Vol. 2, No. 5 - May 1974	**Short Supply**	**Vol. 3, No. 10 - October 1975**	***NYP**
Vol. 2, No. 6 - June 1974	**Short Supply**	**Vol. 3, No. 11 - November 1975**	***NYP**
Vol. 2, No. 7 - July 1974	**Available**	**Vol. 3, No. 12 - December 1975**	***NYP**
Vol. 2, No. 9 - September 1974	**Available**	**Vol. 4, No. 1 - January 1976**	***NYP**
Vol. 2, No. 10 - October 1974	**Available**	**Vol. 4, No. 2 - February 1976**	***NYP**
Vol. 2, No. 11 - November 1974	**Available**	**Vol. 4, No. 3 - March 1976**	***NYP**
Vol. 3, No. 1 - January 1975	**Available**	**Vol. 4, No. 4 - April 1976**	***NYP**
Vol. 3, No. 3 - March 1975	**Short Supply**	**Vol. 4, No. 5 - May 1976**	***NYP**
Vol. 3, No. 5 - May 1975	**Available**	**Vol. 4, No. 6 - June 1976**	***NYP**
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FOR SALE — Back issues of ASTRONOMY: December 1973; January, May, August, October, December 1974; March and April 1975. All in good condition. Price: $3.50 each. Write Donald J. Hamilton, 627 Dodson St., Geneva, IL 60134.

FOR SALE — A. Jaegers heavy duty mount and pedestal; $50.00. 8" f/8 mirror; $40.00. Will ship anywhere in U.S. at no extra cost. Write Mike Hicks, 1006 N. River St., Alma, MI 48801.

FOR SALE — 60mm f/11.7 refractor with accessories, case, optical cleaning kit; $170.00. Newly polished 6" mirror; $40.00. Or both for $190.00. Write Rick Mauderer, R.R. #3, Alden, IA 50006.

FOR SALE — New Bushnell 7 x 50 binoculars with case; $35.00. New 2.4x Dakin Barlow; $35.00. New University Optics 20mm Erfle eyepiece; $22.00. Money orders only; all sent postpaid. Write Charles Hovetter, 485 Cole Ave., Akron, OH 44301.

FOR SALE — 3" Unitron altazimuth refractor with usual accessories; $200.00. Jaegers 80mm spotting scope; $100.00. Both instruments in good condition. You pick up. Contact Samuel Gordon, 4606 72nd Ave., Landover Hills, MD 20784. Phone (301) 577-9064.

FOR SALE — Standard Questar telescope with wide field, basic camera coupling set and Canonflex adapter. All in excellent condition. Price: $950.00 Contact Alan Baurle, 2645 W. Lawson Rd., Marion, IN 46952. Phone (317) 384-7216.

FOR SALE — 12-1/2" x 2-1/4" pyrex mirror blank; $40.00. 10" f/8 Newtonian pyrex mirror, unaluminized; $75.00. Both shipped postpaid. Contact Allen S. Heasley, 6 Jonathan Ln., Youngstown, OH 44511. Phone (216) 793-3461.

FOR SALE — 4" Unitron refractor with equatorial mount and many extras. Good condition. Best offer or will consider partial trade for 5" or larger RFT refractor. Contact Terry S. Bienstock, 615 Derby Ave., Woodmere, NY 11598. Phone (516) 295-3547.

FOR SALE — Sears 2.4" equatorial refractor with 3 eyepieces (4mm, 9mm, 22mm), erector, Barlow, star prism, sun screen, setting circles. Excellent condition. New $150.00; will sell for $65.00 plus shipping. Write Mark Hoxmeier, 3240 Marwick, Long Beach, CA 90808.

FOR SALE OR TRADE — Cave 6" RFT with null figured optics and Edmund clock drive on tripod. Like new. Will trade for comparable priced refractor. Write William Dvorine, M.D., Pikesville Medical Center, 1401 Reisterstown Rd., Pikesville, MD 21208.

FOR SALE OR TRADE — Criterion RV-8 with 7 eyepieces, dynatracker, Barlow. Excellent condition; seldom used; 1-1/2 years old. Best offer over $400.00. Or will trade for new Hi-Fi equipment. Write Stanley J. Swiercz Jr., 7 Summit Ave., Easthampton, MA 01027.

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TRADE — Nikon FTN Photomic and Nikkor lenses (24mm, 50mm f/2, 43-86mm, 200mm). Want quality telescope of equal value. Contact Alan Vega, 25771 Padva Dr., Laguna Hills, CA 92653. Phone (714) 830-9821.

WANTED — Person to finish partially started 8" mirror to an f/8 curve; must be corrected to at least 1/4 wave. Will pay $30.00 plus postage. Also orthoscopic zoom eyepiece (1-1/4" O.D.). Write Kevin Dick, 28911 Hathaway, Livonia, MI 48150.

WANTED — December 1974 issue of ASTRONOMY. Will pay $6.00 if in good condition. Contact Ben Lethco, P.O. Box 600, Rural Retreat, VA 24368. Phone (703) 686-5567.

WANTED — March 1975 issue of ASTRONOMY. Must be in good to excellent condition; will pay up to $4.50. Write Dean Menegas, 1306 Canterbury Ln., Glenview, IL 60025.

WANTED — October, November, December 1973 issues of ASTRONOMY. Will pay $5.00 per issue or $20.00 for complete set (plus postage) if in excellent condition. Write Michael M. Fitzsimmons, 4538 Karole Mn. Dr., Apt. B, Berkeley, MO 63134.

WANTED — 8" or 10" reflector with setting circles, clock drive, slow motion controls. Must be complete, in excellent condition; preferably within driving distance. Send pertinent details to Ranes C. Chakravorty, Veterans Administration Hospital, Salem VA 24153. Phone (703) 981-0316.

WANTED — Brandon eyepieces and Barlow. Write Stephen Pease, 1334 Holmes Dr., Colorado Springs, CO 80909.

WANTED — Celestron 8. Send details to A. Harry Zeeve, Sterling Rd., Harrison, NY 10528. Phone (914) 967-1114.

WANTED — Back issues of ASTRONOMY: September through December 1973; January, February, December 1974. Must be in excellent condition; will pay $3.00 each. Write Ralph Williams, Rt. 1, Box 309, Star City, AR 71667.

WANTED — Back issues of ASTRONOMY: October, November, December 1973; January, February, August 1974. Will pay any reasonable price. Write Bill Yarborough, 106 E. Calhoun St., Clinton, SC 29325.

WANTED — Camera body for astrophotography, Barlow, and finderscope. Reasonable price is a must. Write Robert Zack, Box 55, Intervale, NH 03845.

WANTED — Celestron 8 or Dynamax 8. Send full details to Allen A. Holth, 8211 Dillon, Houston, TX 77017. Phone (713) 649-0228.

WANTED — Back issues of ASTRONOMY: September through December 1973; January and February 1974. Must be in good condition; will pay good price. Write Grover F. Jones Jr., P.O. Box 72, McDermott, OH 45652.

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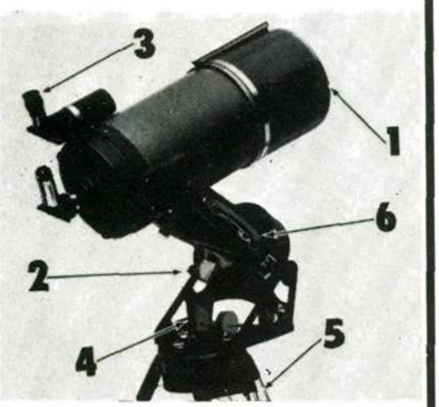

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WANTED — 12.5", 14" or 16" mirror blank either partially ground or new, at reasonable price. For high school physics class project. Also any parts needed to construct a telescope to accomodate the mirror. Contact Robert Williams, 1823 Monroe, Pasco, WA 99301.

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WANTED — Pre-1920 astronomy books including works in foreign languages. Send list of books with prices and condition to Michael J. Crowe, 53155 Oakmont West Dr., South Bend, IN 46637.

WANTED — May and August 1974 issues of ASTRONOMY. Must be intact; prices dependent on condition. Write Wolfram von Kiparski, 17750 Gar Highway, Huntsburg, OH 44046.

WANTED — Plans/pointers for various types of telescopes; any Arthur C. Clarke first editions; information on obtaining spacecraft model kits and space art slides, posters, etc. Write Sven Knudson, 3404 Shady Hill Circle, Temple, TX 76501.

WANTED — Free, old astronomy pictures, charts, graphs, drawings, visual aids needed for senior citizens astronomy class of 35 members. Write Donald B. Miller, c/o Majestic Towers Retirement Center, 1255 Pasadena Ave. S., St. Petersburg, FL 33707.

WANTED — Back issues of ASTRONOMY: September through December 1973; January, February, August, December 1974. Send prices to Gerry Monaghan, Rt. 5, Box 125, Tupelo, MS 38801.

WANTED — October, November, December 1973 issues of ASTRONOMY in very good to excellent condition. Will pay up to $6.50 each. Write Timothy S. O'Boyle, 341 Sheridan Ave., Winchester, VA 22601.

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WANTED — October 1973 issue of ASTRONOMY in good condition; needed to complete collection. Will consider paying up to $4.00 depending on condition. Write John Sikora, 9327 Ferndale Rd., Dallas TX 75238.

WANTED — Reputable individual or firm to repair Tasco 3" refractor, or information regarding self repair of such telescopes. Contact Terry Conti, 4315 Shawnee Trail, Jamestown, OH 45335. Phone (513) 675-6579.

WANTED — Unitron 220-B astrocamera and accessories for 1-1/4" O.D. Please state price and condition. Write Alex Pineda, Box 521, APO NY 09406.

INFORMATION WANTED — About portable 12-1/2" reflector design (to be towed by auto). Attention should center on framework, jacking, shock absorption, and prevention of optical damage by road dust, etc. Write Terry N. Trees, 521 Isabella St., Apt. #3, Oakmont, PA 15139.

INFORMATION WANTED — Plans for radio telescope that can pick up the sun or Milky Way. Write Clinton Laskowski, 3631 E. Underwood Ave., Cudahy, WI 53110.

INFORMATION WANTED — On amateur astronomers and other telescope owners in the Ann Arbor area. Write Hal Bidlack, 1709·Cherokee, Ann Arbor, MI 48104.

INFORMATION WANTED — On astronomy clubs in North Georgia (particularly Fannin and Gilmer counties). Write Cecil Davis Jr., Box 200, Rt. 1, Mineral Bluff, GA 30559.

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STAR DOME

SEPTEMBER

A stunning emblem of the summer sky dominates September's Star Dome. Called the summer triangle, this large three-star pattern is sometimes mistaken for a constellation. In reality, the three stars comprising the triangle are parts of three separate constellation figures.

Glistening almost directly overhead, the cold-blue star Vega in the constellation Lyra the harp marks one corner of the triangle. Moving counterclockwise, you can easily find the star Deneb in Cygnus the swan as the second corner. Below these two stars and at the triangle's apex lies first magnitude Altair in Aquila the eagle.

Each season has a special identifying star pattern: the great square of Pegasus in autumn, the circle of first magnitude stars in winter, and the diamond of Virgo in spring. But the summer triangle has a special magnificence making it quite distinct from other seasonal star patterns.

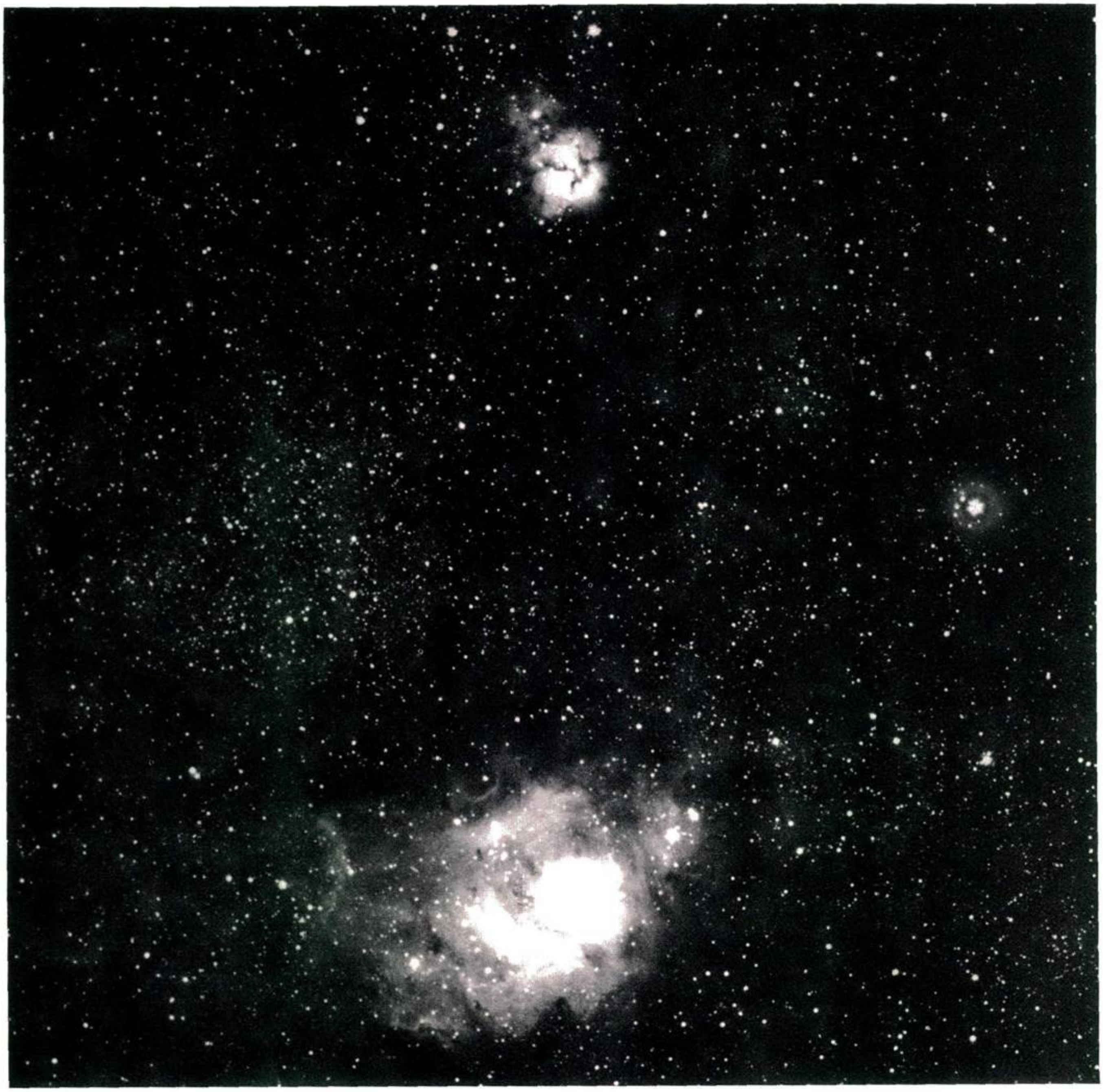
Within the triangle's boundaries Deneb marks the top of a perfectly shaped cross pattern of stars which doubles as the Northern Cross, and Cygnus the swan. Deneb indicates the swan's tail, its outstretched wings fill the crossbar, and a long neck stretches to Cygnus' head at the cross' base. The beautiful double star Albireo lies at the swan's head.

One of the most popular Greek myths concerning Cygnus represents the bird as the swan into which the greatest of all the ancient Greek gods, Zeus, changed himself when he seduced Leda, the wife of King Tyndareus of Sparta. She bore two children by Zeus — Pollux of the Gemini twins, and Helen of Troy. To Tyndareus, she bore Castor (also of the Gemini twins), and Clytemnestra, Agamemnon's wife. The half brothers, Castor and Pollux, were often referred to as the sons of Zeus, and achieved immortal fame in the skies. The half sisters also made names for themselves in the mythology of the Greeks.

The swan has also been linked to the famous story of Phaethon, son of Apollo, and his disastrous attempt to drive the sun chariot across the sky. Phaethon, much to his father's dismay, demanded to take the chariot on its daily course through the heavens to prove to his playmates he was indeed the son of Apollo. Apollo's fiery steeds soon realized they were driven by a mere boy, however, and took their own course — dropping so close to Earth that trees on the mountaintops were set ablaze, oceans began to steam, and fertile lands were changed to deserts. Zeus, realizing the problem, shot one of his thunderbolts at luckless Phaethon, killing him. The boy fell like a shooting star into the river Eridanus. Phaethon's best friend Cygnus was grief-stricken, and dove again and again to recover his comrade. Zeus was so moved by the display he changed Cygnus into a swan so he could dive more easily to recover the body for a proper burial. Finally, when the search proved fruitless, Zeus placed the swan in the sky to immortalize the friendship of the two boys.

The third member of the summer triangle is another winged creature, Aquila the eagle. Dazzling first magnitude Altair, bordered by two faint third and fourth magnitude stars, locates the bird. Unlike Cygnus, it's difficult to imagine any bird occupying Aquila's faint scattering of stars.

A hot, yellow-white star only 18 light-years away, Altair makes a notable summer sky member. A popular stopover for starship travelers in science fiction stories, Altair would be an impressive lord



Two of the sky's most beautiful nebulae, the Trifid (top) and Lagoon (bottom), appear in this 15 minute exposure. Several of these huge clouds of dust and gas lie in the direction of the constellation Sagittarius toward the Milky Way's center. An eight inch Celestron Schmidt camera recorded the pair on Kodak SO-410 film. Photograph by Leo C. Henzl Jr.

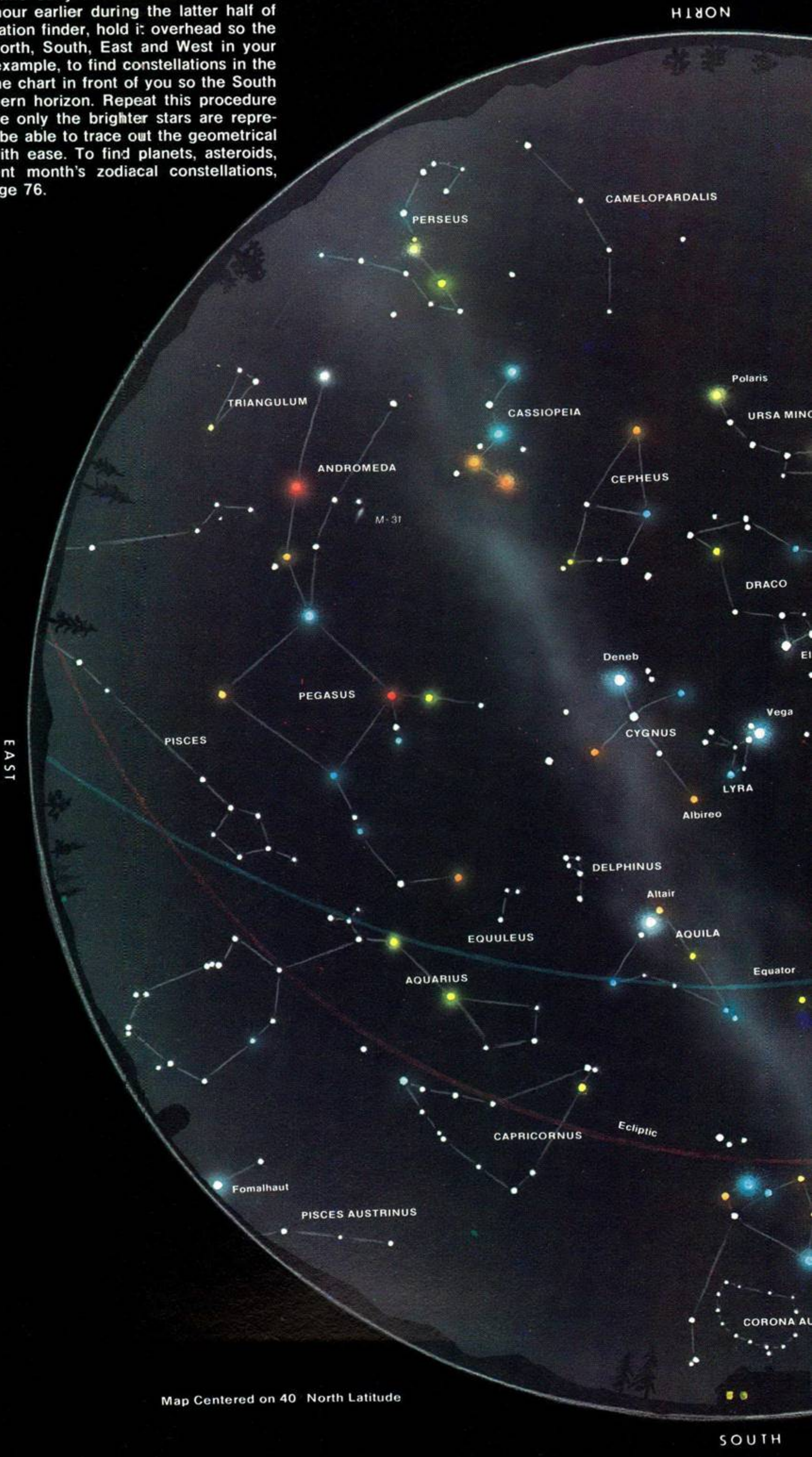
of its solar system (if one exists). Close up, the star would appear twice our sun's diameter and blaze at 10 times its intensity.

The ancient Greeks regarded Aquila the eagle as the pet of Zeus. The bird perched next to the throne of the Greek god, and bore his thunderbolts when Zeus became destructively mischievous with the mortals on Earth.

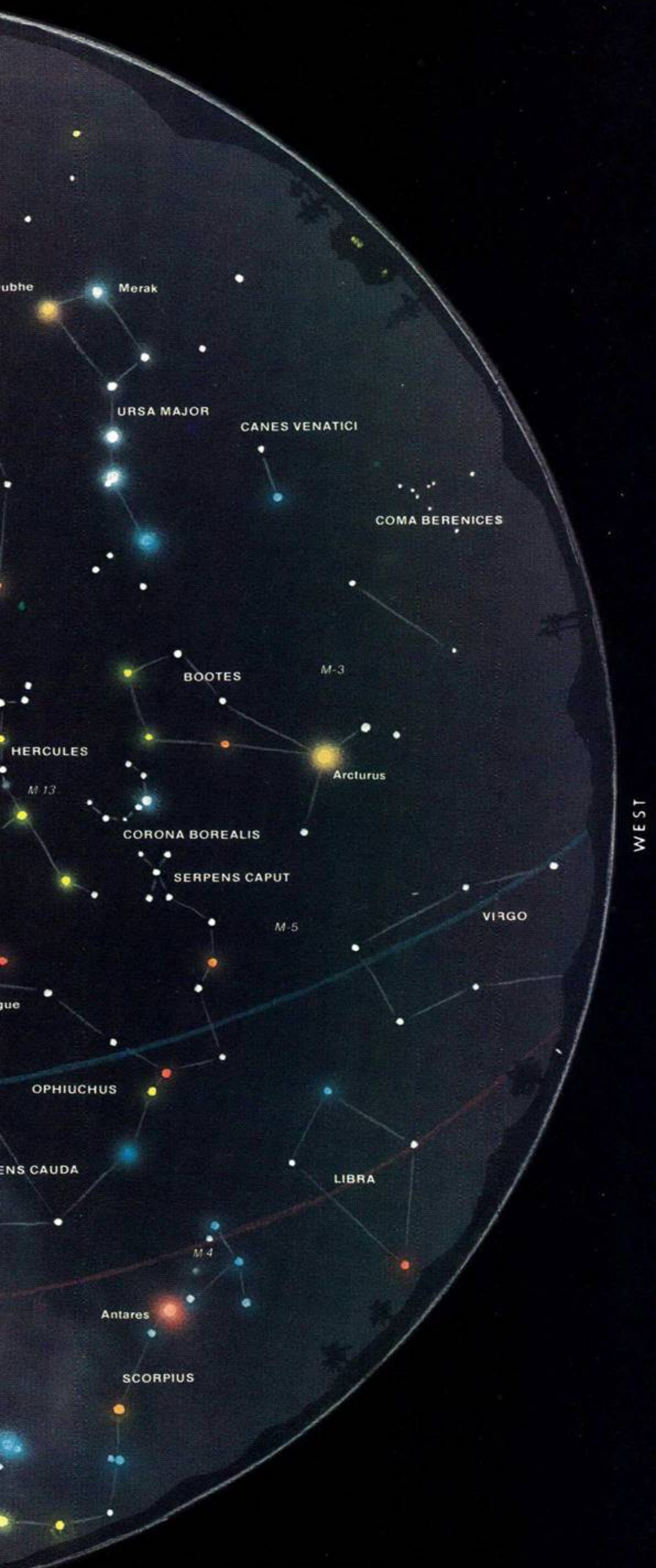
Another tale links the bird with the fate of poor Ganymede, son of Tros, king of Troy. Hebe, royal cupbearer to the gods on Mt. Olympus, earned the displeasure of Zeus with her carelessness, and the king of the gods decided it was time to replace her. In his search the god spied Ganymede, peacefully tending his father's flocks on Mt. Ida. Zeus was struck with the beauty of the boy (the Greeks were quite liberal about such things), and ordered the eagle to swoop down and grab Ganymede in his talons so he could serve as the royal cupbearer. The eagle accomplished the task, and was rewarded with a place among the stars. Zeus changed Ganymede's name to Aquarius and made him a zodiacal constellation.

A tiny but unique pair of constellations lies between Cygnus and Aquila. Easily detectable is a kite shaped pattern of four dim stars identifying Delphinus the dolphin. Even in ancient times, dolphins were regarded as friends of sailors — so

This Star Dome rendering approximates the sky as it appears at about 11 p.m. Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.


NORTH
PERSEUS
CAMELOPARDALIS
TRIANGULUM
CASSIOPEIA
Polaris
URSA MINO
ANDROMEDA
CEPHEUS
M·31
DRACO
Deneb
El
PEGASUS
Vega
EAST
PISCES
CYGNUS
LYRA
Albireo
DELPHINUS
Altair
EQUULEUS
AQUILA
AQUARIUS
Equator
Ecliptic
CAPRICORNUS
Fomalhaut
PISCES AUSTRINUS
CORONA AU
SOUTH

Map Centered on 40° North Latitude



Map by Adolf Schaller

its no surprise a dolphin plays a hero in mythology.

One story tells of the Greek musician Arion escaping a shipful of unfriendly crewmates by riding away on the back of a dolphin. Neptune, god of the sea, immortalized the brave creature by placing him in the heavens as a constellation.

Near Delphinus, a narrow "Y" pattern of five fourth magnitude stars symbolizes Sagitta the arrow. Fortunately, Sagitta does not seem headed toward any particular constellation figure. Perhaps it was just a sloppy shot by Sagittarius the archer, a constellation now low on the southern horizon.

Cygnus and Aquila appear to be flying in opposite directions along the Milky Way, a hazy band of light arching across the heavens like a ghostly rainbow. Summer provides the best opportunity for observing this river of light, created by the combined radiance of millions of stars concentrated within the plane of our galaxy.

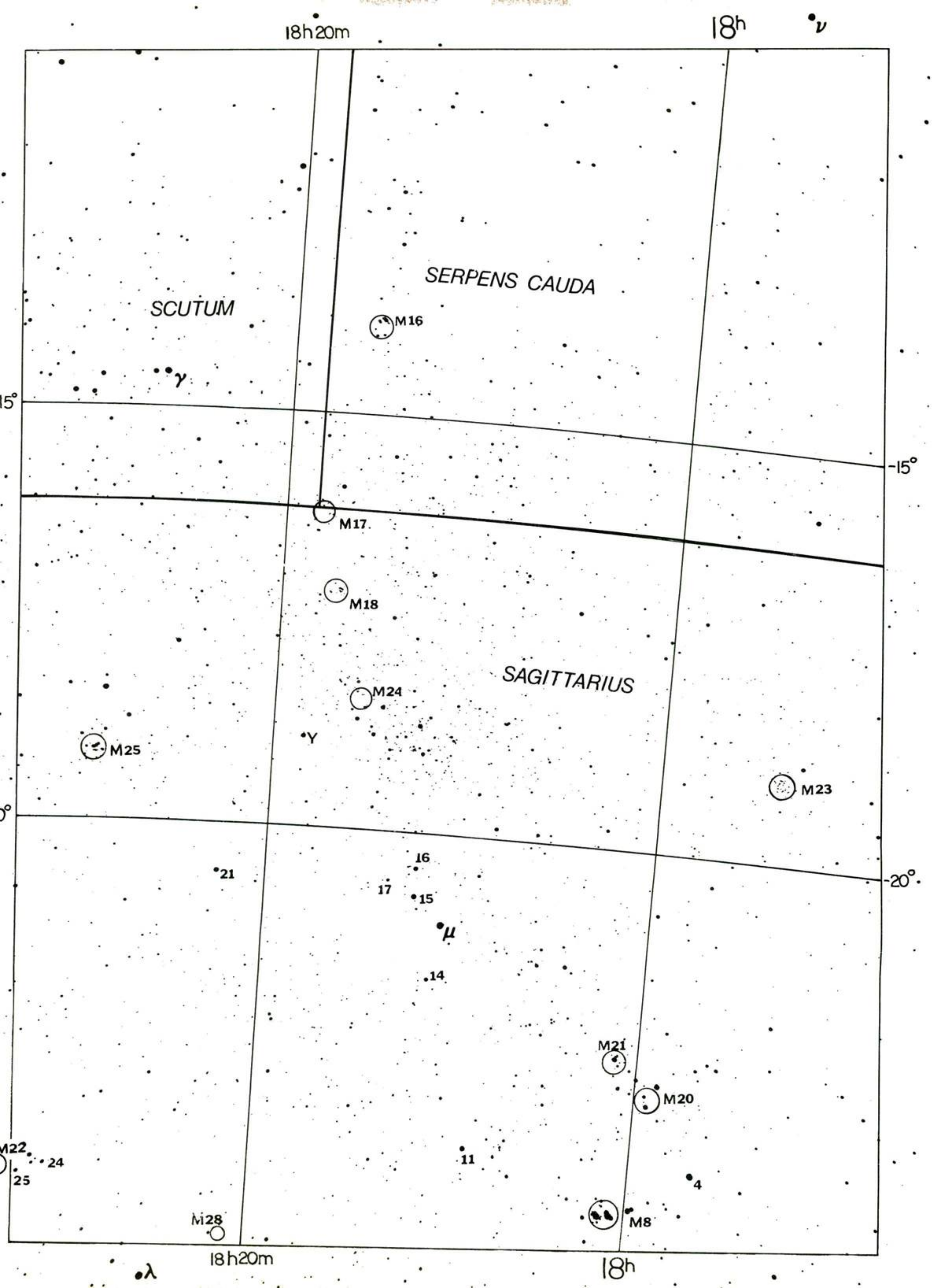
The Greeks regarded the Milky Way as the road to heaven, and created many myths relating to its origin. One concerns Astrea, goddess of justice, who in ancient times ruled the world. When the wickedness of mankind overwhelmed her, she flew to the heavens and became the zodiac's Virgo. In her haste to escape, the sheaf of wheat she held in her hand scattered its grains behind her, creating the Milky Way and the road to the heavens.

Close-Up on the Scutum/Sagittarius Region

The area covered in this month's Star Dome may be small, but for the observer, it's a true delight. The individual stars are not important; the rich backdrop of the Milky Way, the edge-on view of our galaxy, catches all our interest.

On a clear night away from city lights, the galaxy shimmers as a luminous band of light stretching from horizon to horizon. It was called the Milky Way by the ancients — the name used today to describe it. This band of light is best seen in late summer on a moonless night an hour or so after sunset. The Northern Cross in the constellation Cygnus the swan is then directly overhead. Arcturus is on its way down in the west, and in the northeast the W-shaped constellation Cassiopeia is rising. The Milky Way can be traced through Cassiopeia and Cygnus, and then down to the horizon through Aquila, Sagittarius and Scorpius. Between Cygnus and Sagittarius, two bands can be distinguished — separated by a dark space called the Great Rift, a huge cloud of obscuring dust and gas.

The sun is located in one of the spiral arms of the galaxy, approximately 30,000 light-years from the center. The galaxy itself is about 100,000 light-years in diameter and 5,000 light-years "thick".


18h20m
18h
ν
SCUTUM
SERPENS CAUDA
M16
γ
15°
-15°
M17
M18
SAGITTARIUS
M24
Y
M25
M23
0°
-20°
16
21
17
15
μ
14
M21
M20
M22
24
25
11
4
M28
M8
18h20m
18h
λ

The entire spiral rotates, with our solar system completing one trip around the center in 200 million years. It has gone around the galaxy about 20 times during the 4.6 billion years of its existence.

Nowhere does the Milky Way glow more brilliantly than in Sagittarius and Scorpius, and nowhere else does it show such great apparent width. Astronomer Harlow Shapley first determined the center of the galaxy or the galactic nucleus lay in the general direction of the Sagittarius star clouds. We don't see the bright nucleus because a dense blanket of dust lying in the central plain of the Milky Way conceals it. Just north of this center is one of the brightest areas of the Milky Way, the Scutum Cloud.

A powerful pair of binoculars or a richest field telescope will reveal the Milky Way as a concentration of thousands upon thousands of bright stars. Sweeping the edge-on view of our galaxy reveals many of the faint, individual pinpricks of light. Deep sky objects abound. Open clusters (containing between 20 and 2,000 stars) lie almost without exception within a few degrees of the galactic band. The Scutum/Sagittarius region is rich in these clusters. Also found in and near the Milky Way are glowing clouds of gas and dust known as nebulae. The Trifid, Omega and Lagoon (featured in Eyepiece Impressions) are three prime examples of nebulae found in the Scutum/Sagittarius region. These concentrations of gas and dust, called emission nebulae, are illuminated by the radiation of young, hot stars embedded in them.

EYEPIECE IMPRESSIONS

All of the following clusters and nebulae lie within just a 10 degree expanse of sky centered about the galactic equator — the plane or "Great White Way" of our Milky Way galaxy — near the fourth magnitude star Mu (μ) Sagittarii. Mu itself is about five degrees northwest of the famed teapot outline of Sagittarius. All that is needed to enjoy these wonders is a telescope charged with a low (30 to 50) power wide field eyepiece and a dark transparent night.

M-16

Our exploration of this superb region begins with the first of three objects sharing a dual nature — that of a bright diffuse nebula and an involved open cluster of stars. This is M-16, slightly more than two degrees west and a bit north of fourth magnitude Gamma (γ) Scuti.

The cluster itself has some 55 suns scattered over an area nearly the size of the full moon with the combined light of a 6.5 magnitude star. Like many of the other objects in this area, M-16 is near the limit of the unaided eye and an easy subject in 7 x 50 binoculars.

The nebulous component — known as the Eagle nebula from its striking likeness to the bird in photos — is a rather difficult object to see visually. Seeing the Eagle depends just as much on good sky conditions (transparency) and training of the eye as on telescopic aperture. Its outline can be glimpsed in a four inch scope with averted vision and slow sweeping back and forth. The cluster stars appear enshrouded in a faint mist or fog.

Viewing the dark "fingers" of gas and dust seen against the nebula background in pictures is as difficult as picking out the elusive Horsehead nebula in Orion — a real feat even in the largest amateur instruments! Color photographs of the Eagle and the other two nebulae described this month (Trifid and Lagoon) appeared in the June 1975 issue of ASTRONOMY.

Observers of the past — before the advent of photography — recognized M-16 as simply an open cluster. Webb logged this object as a "grand cluster" with no mention at all of the involved nebula. An equal double star (both components are white) lies near the center of the group.

M-17

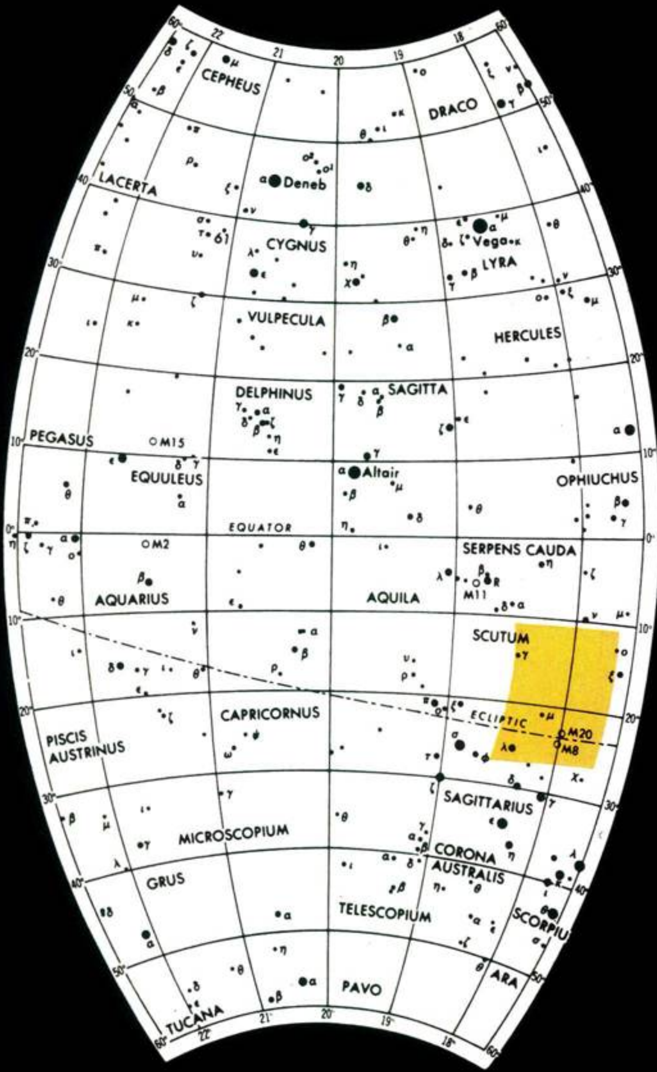
Nebula lovers disappointed with M-16 should sweep two degrees south of the Eagle where they will encounter a cosmic cloud bright enough to be seen in small finders and binoculars. This is the well-known Omega or Horseshoe nebula (M-17), named for the arch of nebulosity from which extends a long bright ray or bar, giving this object the appearance of the figure "2" with a long bottom.

M-17 looms large on dark nights, extending over an area greater than the full moon (46 minutes of arc by 37 minutes). In eight inch and larger reflectors, the Horseshoe ranks as one of the finest diffuse nebulae in the heavens — second only to the Orion nebula and perhaps the Lagoon for northern hemisphere observers.

A 10 inch reflector at 80 power shows a long bright ray, hooked at one end, and crossed by dark obscuring lanes of dust. A three inch refractor at 45 power will show the ray, but careful attention will also show the loop. Barns sums it up perfectly: "Interesting with low power, but with increased magnification an exquisite object."

Like M-16, the Horseshoe can be found listed in catalogs as both a nebula and a cluster. The Milky Way background is intensely rich in this region and local concentrations of stars are difficult to distinguish from actual physical clusters. A bright sprinkling of suns is strung out beneath the nebulous bar, accounting for M-17's entry as a cluster.

Admiral Smyth long ago described this object in his six inch refractor as "a magnificent, arched, and irresolvable nebulosity — in a splendid group of stars." The group is listed as 22 minutes in apparent size with nearly three dozen members. The combined object lies some 3,000 light-years away in the banked star clouds of the summer Milky Way.


CEPHEUS
DRACO
LACERTA
Deneb
CYGNUS
Vega
LYRA
VULPECULA
HERCULES
DELPHINUS
SAGITTA
PEGASUS
M15
EQUULEUS
Altair
OPHIUCHUS
EQUATOR
M2
SERPENS CAUDA
AQUARIUS
AQUILA
M11
SCUTUM
CAPRICORNUS
ECLIPTIC
M20
M8
PISCIS AUSTRINUS
SAGITTARIUS
MICROSCOPIUM
CORONA AUSTRALIS
GRUS
TELESCOPIUM
SCORPIUS
PAVO
ARA
TUCANA
22
21
20
19
18
60°
50°
40°
30°
20°
10°
0°

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet

α	**Alpha**	η	**Eta**	ν	**Nu**	τ	**Tau**
β	**Beta**	θ	**Theta**	ξ	**Xi**	υ	**Upsilon**
γ	**Gamma**	ι	**Iota**	ο	**Omicron**	ϕ	**Phi**
δ	**Delta**	κ	**Kappa**	π	**Pi**	χ	**Chi**
ϵ	**Epsilon**	λ	**Lambda**	ρ	**Rho**	ψ	**Psi**
ζ	**Zeta**	μ	**Mu**	σ	**Sigma**	ω	**Omega**

Star Magnitudes
–1
0
1
1½
2
2½
3
3½
4
5
Cluster or Nebula
Variable Star

Map from **Guideposts to the Stars**; reprinted permission of MacMillan Publishing Co., ©1972 by Leslie C. Peltier.

TABLE OF OBJECTS — SCUTUM/ SAGITTARIUS REGION

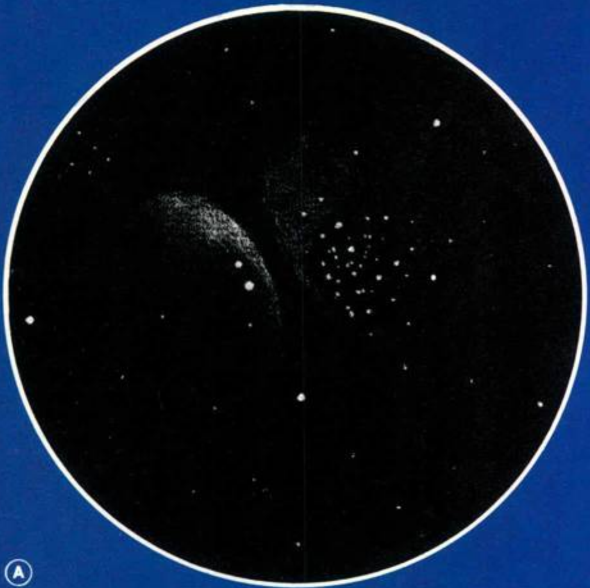
Object	Type	Magnitude	Size	R.A.	(1950)	Dec.
NGC-6469 (Sagittarius)	open cluster	8.0	12'	17^h56^m		-22°20'
* M-23 (Sagittarius)	open cluster	6.9	25'	17^h54^m		-19°01'
* M-20 (Sagittarius)	diffuse nebula	—	29' x 27'	17^h59^m		-23°02'
M-21 (Sagittarius)	open cluster	6.5	10'	18^h02^m		-22°30'
* M-8 (Sagittarius)	diffuse nebula	—	60' x 35'	18^h02^m		-24°20'
* NGC-6530 (Sagittarius)	open cluster	6.3	10'	"		"
* M-16 (Serpens)	diffuse nebula/	—	35' x 28'	18^h16^m		-13°48'
	open cluster	6.4	25'	"		"
M-24 (Sagittarius)	open cluster	4.6	4'	18^h16^m		-18°27'
* M-18 (Sagittarius)	open cluster	7.5	12'	18^h17^m		-17°09'
* M-17 (Sagittarius)	diffuse nebula/	—	46' x 37'	18^h18^m		-16°12'
	open cluster	7.5	22'	"		"
M-25 (Sagittarius)	open cluster	6.5	40'	18^h29^m		-19°17'
NGC-6645 (Scutum)	open cluster	8.5	10'	18^h30^m		-16°56'

* Detailed description in Eyepiece Impressions

M-18

Just a degree south of M-17 is another fine gathering of suns. This is M-18, rather sparse and small as clusters go — having only a dozen stars in an area 12 minutes in extent. The higher the magnification used, the less striking this cluster becomes. A 2.4 inch (60mm) refractor at 30 power seems just about right and shows a splash of bright and faint points of light flickering like fireflies in the night.

Many classic observers like Olcott and Webb use the term "glorious field" in their descriptions of M-18, the latter adding that "...a region of surpassing splendor" lies to the south. How very cold the statistics of modern astronomy seem in comparison with the excited commentaries made at the eyepiece by men like these!



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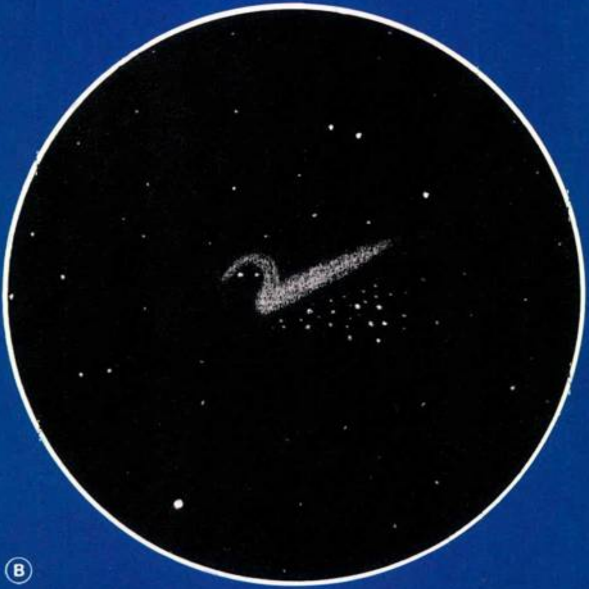

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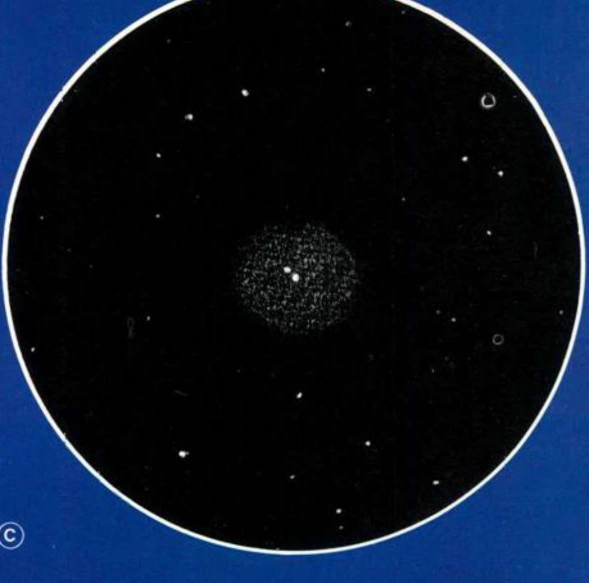


Ⓒ

Ⓐ
The well-known Lagoon nebula offers a fine sight in any instrument from binoculars to large telescopes. It can even be seen with the unaided eye on a good night. The nebulous patch is traversed by a huge dark rift, and a striking open cluster lies to one side in this one degree field of view. This drawing reveals the nebula as seen through a four inch Edmund reflector at 40 power. Artwork by James Mullaney.

Ⓑ
A long bright ray or bar extending from an arch of nebulosity gives the Omega or Horseshoe nebula its name. Bright enough to be seen in small finders and binoculars, the nebula looms over an area greater than the full moon. Seen in a one degree field at 45 power through a six inch Cave Astrola telescope, the nebula ranks as one of the finest diffuse objects in the sky. Artwork by James Mullaney.

Ⓒ
The Trifid nebula in a one degree field at 50 power is not nearly as striking as it appears in telescopes of larger aperture. Its faint light is spread over a large area, and the only distinctive feature really visible is a bright, close double star situated near the nebula's center where the rifts meet. This view is through a five inch Celestron. Artwork by James Mullaney.

M-24

One degree southwest of M-18 is a closely knit family of 50 stars in an area only four minutes of arc across, together having a combined magnitude of 4.6. Inspiring and charming as classic descriptions of deep sky objects are, they do occasionally present puzzles today as well. In the case of M-24, Barns called this group "...giant cluster". But actually it is quite tiny as clusters go and is difficult to pick out from the legions of surrounding stars. A bright star near its edge serves as a guide beacon to this elusive object.

It seems likely that Barns — as do many observers today — mistook the enormous star cloud in which M-24 is embedded for the tiny cluster itself. The cloud is visible to the unaided eye and becomes a glorious object with the slightest optical aid — "as a kind of protuberance of the galaxy", in the words of Webb.

M-23

Five degrees due west of M-24 is yet another open star cluster — this one designated M-23. Both large (25 minutes of arc) and rich (more than 120 stars), it seems even more prominent than its published magnitude of 6.9 suggests. Its outline is somewhat elongated, and the individual stars have a very uniform appearance in brightness.

In six and eight inch reflectors, this stellar commune is a stunning sight. Interestingly, big clusters like M-23 are often quite disappointing when viewed in large observatory instruments due to their restricted fields of view. Like the brighter double stars, open clusters often look better in a small backyard telescope than in the 200 inch reflector at Mt. Palomar.

Webb describes M-23 as a "grand low power field" and points out that its location is "announced by increasing number" — a sudden jump in star density as we approach the cluster's edge. And this time we agree completely with Barns in calling M-23 a "blazing wilderness of starry jewels!" The cluster lies at a distance of more than 2,000 light-years from us, over 12,000,000,000,000,000 miles away in the depths of space.

M-20

Continuing our trip down the Milky Way, three degrees southwest of Mu Sagittarii, we find the fainter of two famous diffuse nebulae only two degrees apart. This is the often pictured rose and blue cloud of gas known as the Trifid nebula, M-20. Photos show a bright circular patch (29 minutes of arc by 27 minutes) crossed by three intensely dark rifts of obscuring matter which meet near its center.

M-20 is disappointing in small telescopes. Its faint light is spread over an extended area, making it difficult to assign an exact magnitude to this and other diffuse nebulae (hence the gaps in our selected objects table). With the use of averted vision and slow sweeping back and forth across the object, a four inch reflector at 40 power reveals the Trifid to be much larger than it seems at first inspection. A bright close double star is situated near the nebula's center where the rifts meet — its overexposure on photos resulting in an apparent bright core.

At least an eight inch telescope is required for a satisfactory view. Webb in his nine inch reflector noted: "Nebula imperfectly seen by Smyth as well as myself; rather low" — which it is at the latitude of Great Britain. He does add, however, that M-20 is a "very curious object." Barns, at a much lower latitude in the clear skies of California, saw it quite differently with his 10 inch reflector: "A dark-night revelation, even in modest apertures. Bulbous image trisected with dark rifts of interposing opaque cosmic dust clouds."

Nebulae like the Eagle, Trifid and Lagoon (described below) are in reality giant stellar incubators in which new stars are being born right before our eyes! Even though the light we see from M-20 has been traveling through space for more than 35 centuries to reach us, the cloud looks much now as it did then, for centuries are but a second in the life of a star.

M-8

Just two degrees south of M-20 is M-8, the well-known Lagoon nebula. Unlike its neighbor, this object is anything but disappointing. Although more distant than the Trifid (4,500 light-years), it is much brighter and presents a fine sight in any instrument from binoculars to large amateur scopes. It can even be seen with the unaided eye on a good night.

Another combination object, M-8 consists of a large (60 minutes by 35 minutes) nebulous patch traversed by a colossal dark rift, with a striking open cluster (NGC-6530) of several dozen suns to one side. The dark gulf, giving rise to this object's name, is easily seen on transparent nights in three and four inch telescopes. A six inch or larger glass allows glimpses of structure within the nebula, while 10 and 12 inch reflectors show hints of actual color. John Herschel even saw milky streaks and loops within the cloud with his 18 inch metal-mirror reflector.

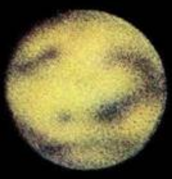
While in this region, slowly sweep back and forth across the dense star clouds massed near our galaxy's nucleus. Wonders far too numerous to mention will pass in review — an incredible profusion of colorful double and multiple suns, star chains, open and globular clusters, diffuse and planetary nebulae, red variables and old novae, and even an occasional galaxy seen through gaps in the star clouds.

That a combination of glass and metal and other Earthly things should reveal to the human eye such celestial glories forces us to agree with Emerson. He wrote, "Of all tools, the observatory (telescope) is the most sublime."

Planet Finder

Ⓒ Cere

Sept.	1	15
R.A.	0^h09^m	0^h00
Dec.	-0° 42'	-3° 45
Mag.	+ 8.4	+ 8.4



Ⓐ Mercury

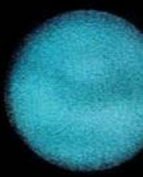
Sept.	1
R.A.	12^h10^m
Dec.	-2° 04'
Mag.	+ 0.2

Ⓑ Mercury

Sept.	15
R.A.	13^h05^m
Dec.	-10° 06'
Mag.	+ 0.4

Ⓜ Mars

Sept.	1	15
R.A.	4^h36^m	5^h08^m
Dec.	+ 21° 02'	+ 22° 09'
Mag.	+ 0.2	+ 0.1



Ⓝ Neptu

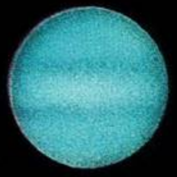
Sept.	15
R.A.	16^h30
Dec.	-20° 1
Mag.	+ 7.7

SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

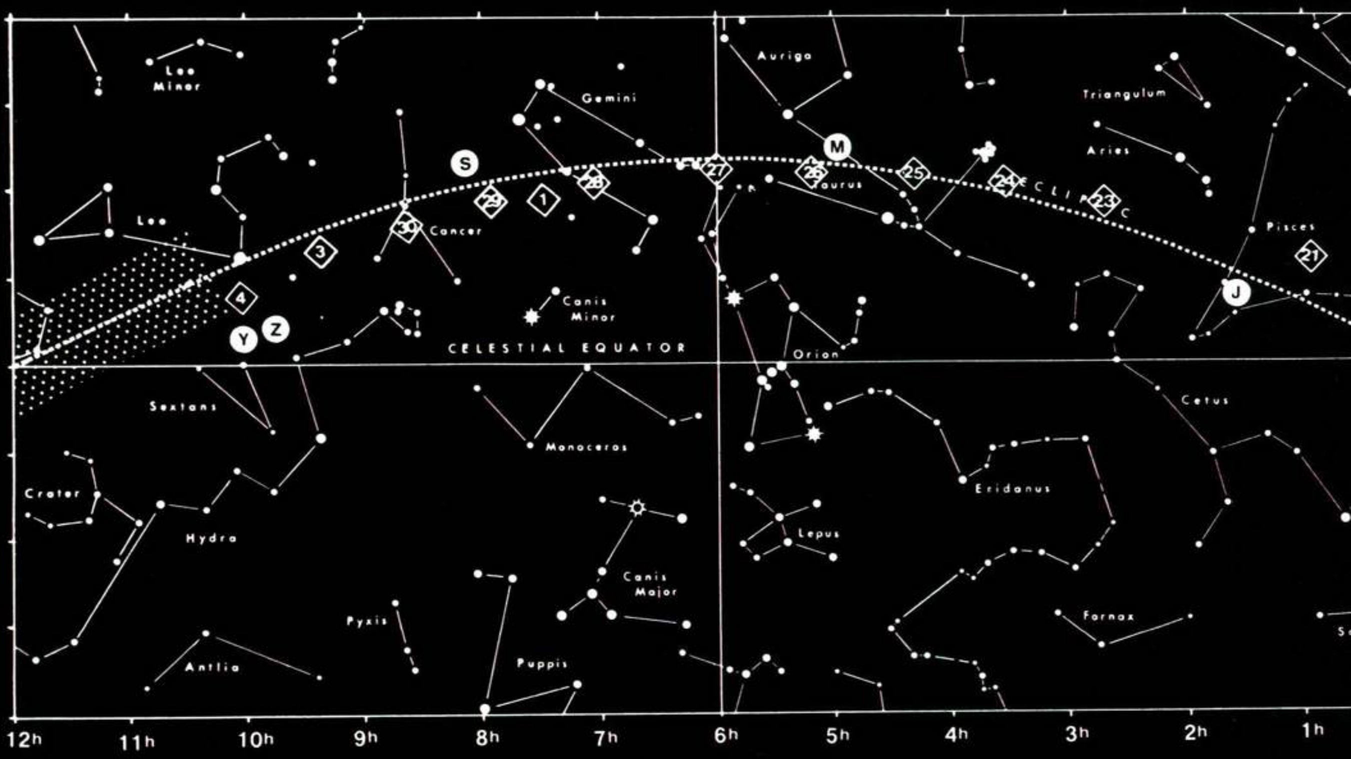
Ⓢ Saturn

Sept.	1	15
R.A.	8^h02^m	8^h08^m
Dec.	+ 20° 30'	+ 20° 13'
Mag.	+ 0.5	+ 0.5



Ⓤ Uranus

Sept.	15
R.A.	13^h53^m
Dec.	-11° 07'
Mag.	+ 5.5


Leo Minor
Leo
Gemini
Auriga
Triangulum
Aries
Taurus
ECLIPTIC
Pisces
Cancer
Canis Minor
CELESTIAL EQUATOR
Orion
Sextans
Monoceros
Cetus
Eridanus
Crater
Hydra
Lepus
Canis Major
Pyxis
Antlia
Puppis
Fornax
S
M
J
Y
Z
1
3
4
21
23
24
25
26
27
28
29
30
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec . = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag . = magnitude, a

September 1975

Vesta

ept.	1	15
.A.	$0^{h}12^{m}$	$0^{h}06^{m}$
ec.	-10° 45'	-12° 26'
ag.	+ 6.2	+ 6.2

Ⓙ Jupiter

Sept.	1	15
R.A.	$1^{h}31^{m}$	$1^{h}27^{m}$
Dec.	+ 7° 57'	+ 7° 29'
Mag.	-2.3	-2.4

Ⓨ Venus

Sept.	1
R.A.	$9^{h}57^{m}$
Dec.	+ 3° 22'
Mag.	-3.6

Ⓩ Venus

Sept.	15
R.A.	$9^{h}41^{m}$
Dec.	+ 6° 24'
Mag.	-4.0

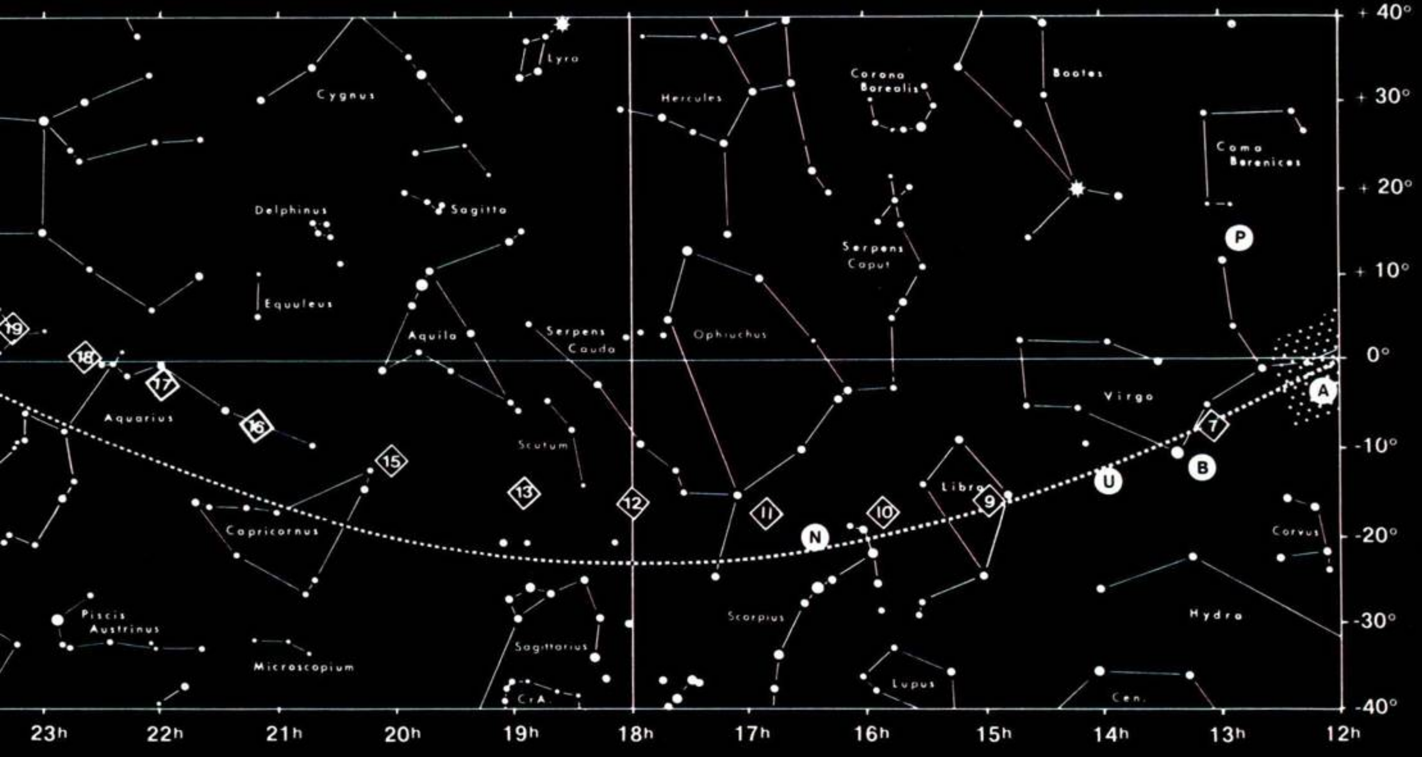
Ⓟ Pluto

ept.	15
.A.	$12^{h}56^{m}$
ec.	+ 11° 46'
ag.	+ 14

First Quarter
Sept. 12

Full Moon
Sept. 20

Last Quarter
Sept. 28


+ 40°
+ 30°
+ 20°
+ 10°
0°
-10°
-20°
-30°
-40°
Lyra
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
Delphinus
Sagitta
Serpens Caput
P
Equuleus
Aquila
Serpens Cauda
Ophiuchus
19
18
17
16
15
13
12
11
10
9
7
A
B
U
N
Aquarius
Scutum
Virgo
Libra
Capricornus
Corvus
Piscis Austrinus
Microscopium
Sagittarius
Scorpius
Hydra
Lupus
CrA.
Cen.
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

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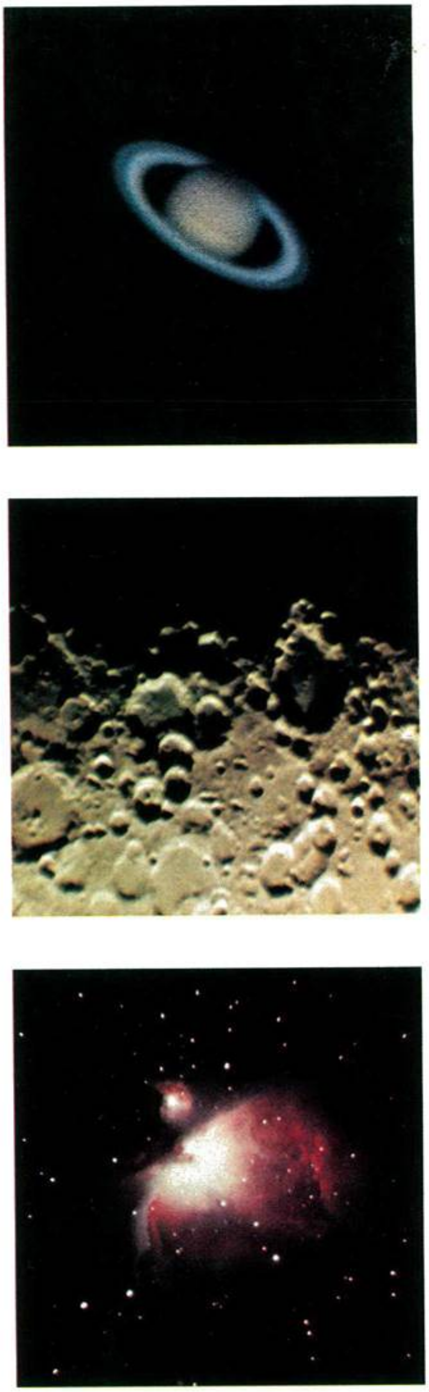

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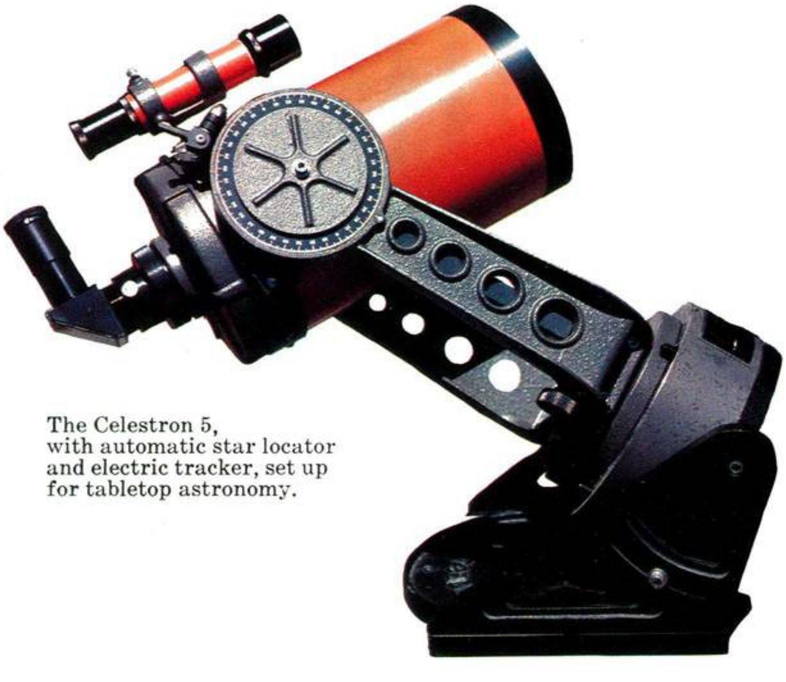

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